THE WEATHER AND CIRCULATION OF APRIL 1957 [1]

A Stormy Month over the United States Characterized by Two Contrasting Temperature Regimes

JAMES F. ANDREWS

Extended Forecast Section, U. S. Weather Bureau, Washington, D. C.

1. INTRODUCTION

April is frequently a month of violent, turbulent weather in many areas of the United States. April of 1957 was no exception, but it was unusual in that the two halves of the month were associated with sharply differing weather regimes. Unseasonable cold with record snows in some northern areas prevailed quite generally during the first half of April over the eastern two-thirds of the nation. Near mid-month this wintry weather was replaced by summerlike conditions with temperatures far above the seasonal normals. In central and eastern Texas excessive rains fell, while very dry weather prevailed in the East during the last half of the month. These pronounced changes in weather were related to an equally pronounced transition in the mid-tropospheric circulation.

It has been common practice in this series of articles to discuss the weather and circulation in terms of the half-monthly patterns. This month lends itself particularly well to such a treatment in view of the mid-month reversal which occurred.

2. CIRCULATION OF APRIL 1–15, 1957

The 15-day mean 700-mb. chart for the first half of April (fig. 1A) shows a mean trough in the central part of the United States, in much the same position it occupied during March [3]. As in March, the mean trough-ridge systems generally displayed little amplitude and the westerlies across North America were somewhat south of normal, with the mean jet stream axis remaining over the Gulf States (fig. 2A).

Blocking, which operated strongly over eastern Canada during March [3], spread westward in typical fashion [7] to Alaska and the eastern Pacific. In early April (fig. 1A) it was represented by the large area of positive 700-mb. height anomaly with centers in eastern Canada (+390 ft.) and the eastern Aleutian Islands (+360 ft.). The westward extension of the Canadian block was associated with a difluent pattern in the eastern Pacific. During this period a new block made its appearance in the North Atlantic. This is shown as a closed anticyclone over Great Britain, along with a height anomaly center of +370 ft.

[1] See Charts I-XVII following p. 140 for analyzed climatological data for the month.

3. EARLY APRIL WEATHER IN THE UNITED STATES

UNSEASONABLE COLD

It has been indicated above that the general character of the circulation changed but little over the United States from March to the first half of April. Similary the related average weather conditions displayed considerable persistence for the two periods.

There was, however, intensification and enlargement of the area of subnormal temperatures in the United States from March to mid-April. In figure 3A is shown the observed temperature anomaly for the first 15 days of April. The entire Nation east of the Continental Divide, except Florida and the immediate Atlantic and Gulf coasts, experienced temperatures considerably below the seasonal normals, with the greatest departures (10° F. or more) occurring in the Central Plains. The coldest weather of April (relative to normal) in the United States occurred from the 10th to the 15th, with daily temperatures as much as 30° F. below normal in parts of Oklahoma and Texas. From Nebraska southward many areas reported this to be the coldest weather ever experienced so late in the season (records date back to 1887). Some typical temperatures (in ° F., and all late-season records) were: 9° at Valentine, Nebr., on the 12th; and 18° at Springfield, Mo., 20° at Oklahoma City, Okla., and 31° at Dallas, Tex., all on the 13th.

This vast area of unseasonable cold can be related to a deeper than normal trough in the United States and to northeasterly anomalous flow that extended from western Canada to the central United States (fig. 1A). Since this anomalous flow was at right angles to the normal thickness isopleths (1000 mb.–700 mb.) [10], it resulted in strong cold advection [8]. The failure of cold polar air-masses which moved into the United States from central Canada to penetrate west of the Divide resulted in temperatures near or slightly above normal in the Far West (figs. 1A and 3A). In the Southeast southwesterly anomalous flow and above normal 700-mb. heights were associated with temperatures near or above seasonal normals.

PRECIPITATION AND STORMINESS

The precipitation pattern for the first 15 days of April (fig. 4A) shows that the heaviest amounts fell in the eastern half of the Nation, where totals of 4 inches or

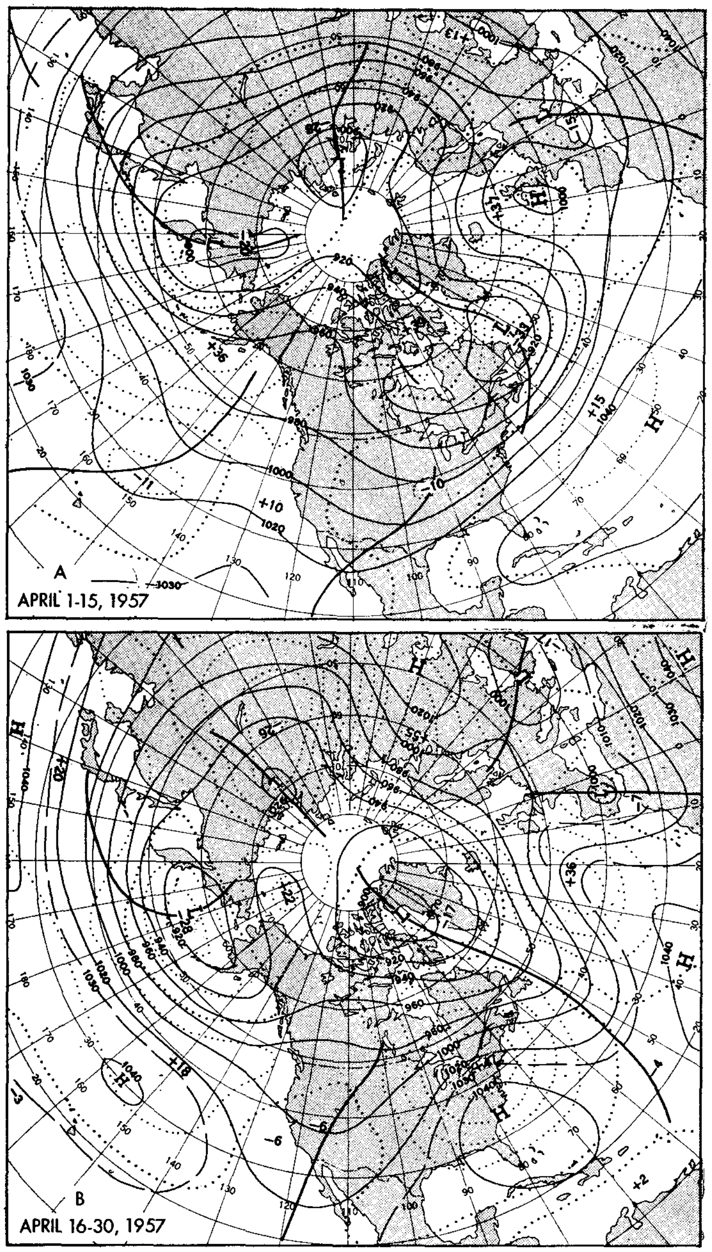


FIGURE 1.—Fifteen-day mean 700-mb. height contours (solid lines) and departures from normal (dotted lines) (both in tens of feet) for (A) April 1–15, 1957, and (B) April 16–30, 1957. Disappearance of the eastern Pacific trough and rapid development of ridge conditions in the eastern United States during second half of month were related to sharp changes in weather regime.

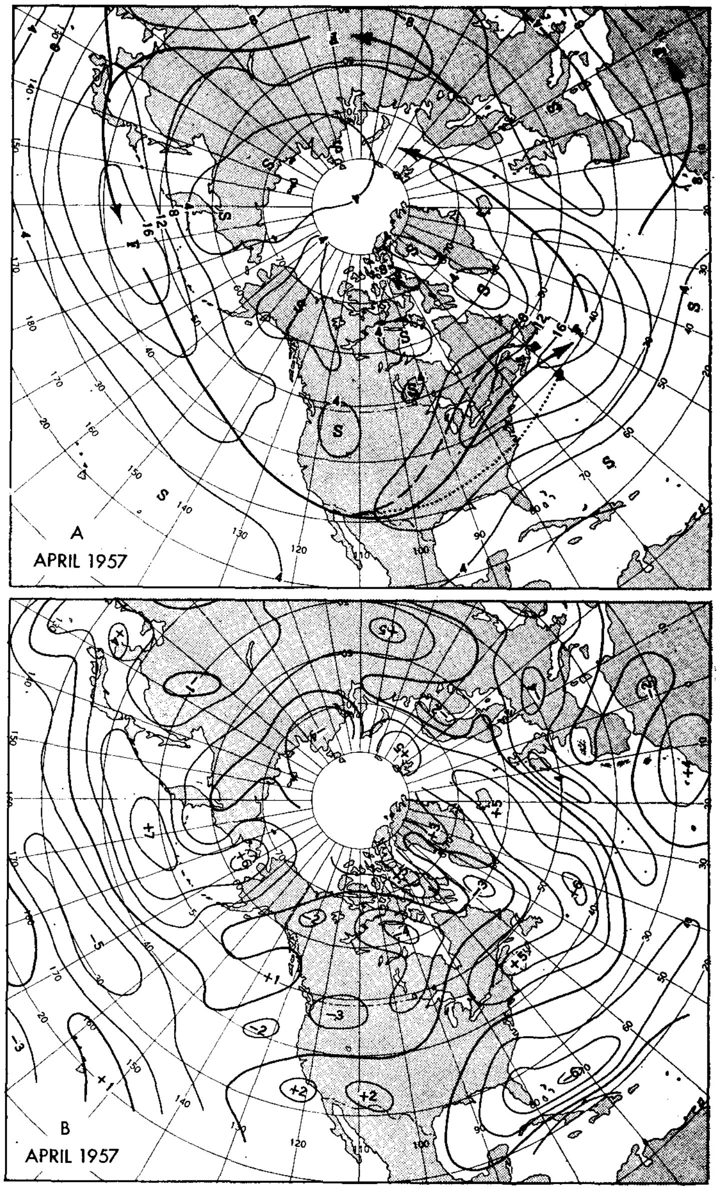


FIGURE 2.—(A) Mean 700-mb. isotachs and (B) departure from normal wind speed (both in meters per second) for April 1957. In (A) position of the primary jet axis is given by solid arrow for the month as a whole, by dotted arrow for first half of month, and by dashed arrow for second half of month. Rapid northward displacement of the westerly jet stream axis over eastern United States from the first half to the last half of the month was associated with pronounced surface warming and drying.

more were common from the Ohio Valley to the Gulf of Mexico. As much as 9 inches was observed at Mobile, Ala. Heavy amounts (3 inches or more) also fell along the eastern slopes of the central Rockies and along the north Pacific coast. The Plains States and most of the Southwest received additional precipitation to further alleviate the drought. In the Far Southwest no rainfall was observed during this period.

This nationwide precipitation pattern can be related quite readily to the corresponding half-monthly 700-mb. chart (fig. 1A) in terms of Klein's schematic precipitation model [4]. Heavier amounts in the East and Southeast were associated with confluence and stronger than normal southwesterly flow which advected moisture from the Gulf of Mexico. To the west of the trough, precipitation was mostly light as a result of northwesterly flow which was stronger than normal.

An exception was along the eastern slopes of the Central Rockies, where orographic lifting and overrunning of polar airmasses by tropical airmasses from the Gulf of Mexico

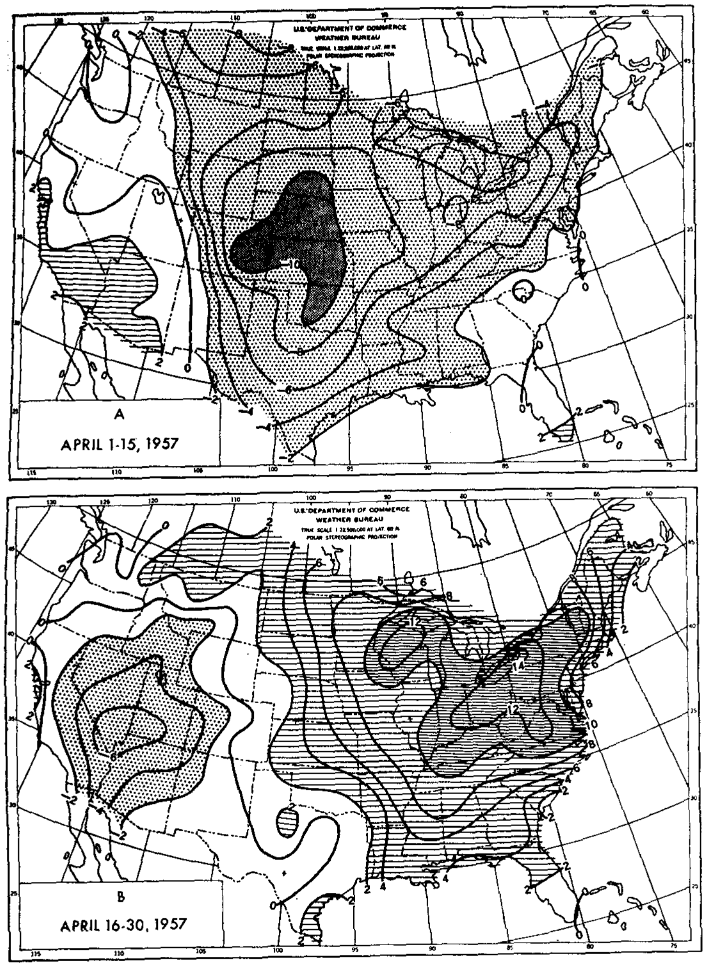


Figure 3.—Departure of average temperature from normal (° F.) for (A) April 1–15, 1957, and (B) April 16–30, 1957. The sharp reversal from a cold to a warm regime east of the Continental Divide, with an opposite change in the West, was one of the outstanding features of the month.

resulted in heavy precipitation, much of which was in the form of snow. Most of this snow fell during two storms, both having their origin in the Southwest about 1 week apart (fig. 5A). Some typical snowfall amounts were: 19 inches (April 1–3) at Lander, Wyo., and 17 inches (April 2) at Denver, Colo. The moderate to heavy snows resulting from these storms extended eastward with several cities, including Sioux Falls, S. Dak (10.7 in.), Fort Wayne, Ind. (10.6 in.), and Toledo, Ohio (12.0 in.), establishing new total snowfall records for April. Unseasonable snow also fell along the east coast when a South Atlantic coastal storm helped establish new late-season snowfall records at Lynchburg, Va. (2.8 in.) and Atlantic City, N. J. (1.0 in.) on the 13th (fig. 5A).

Severe weather activity, in the form of thunderstorms, heavy rain, hail, and strong winds, was frequent during the period April 1–15 from Texas to the Middle Atlantic coast. Much of this storminess was frontal in nature, as suggested by the high frequency of fronts in that area (fig. 6). Tornado activity also occurred as far north-

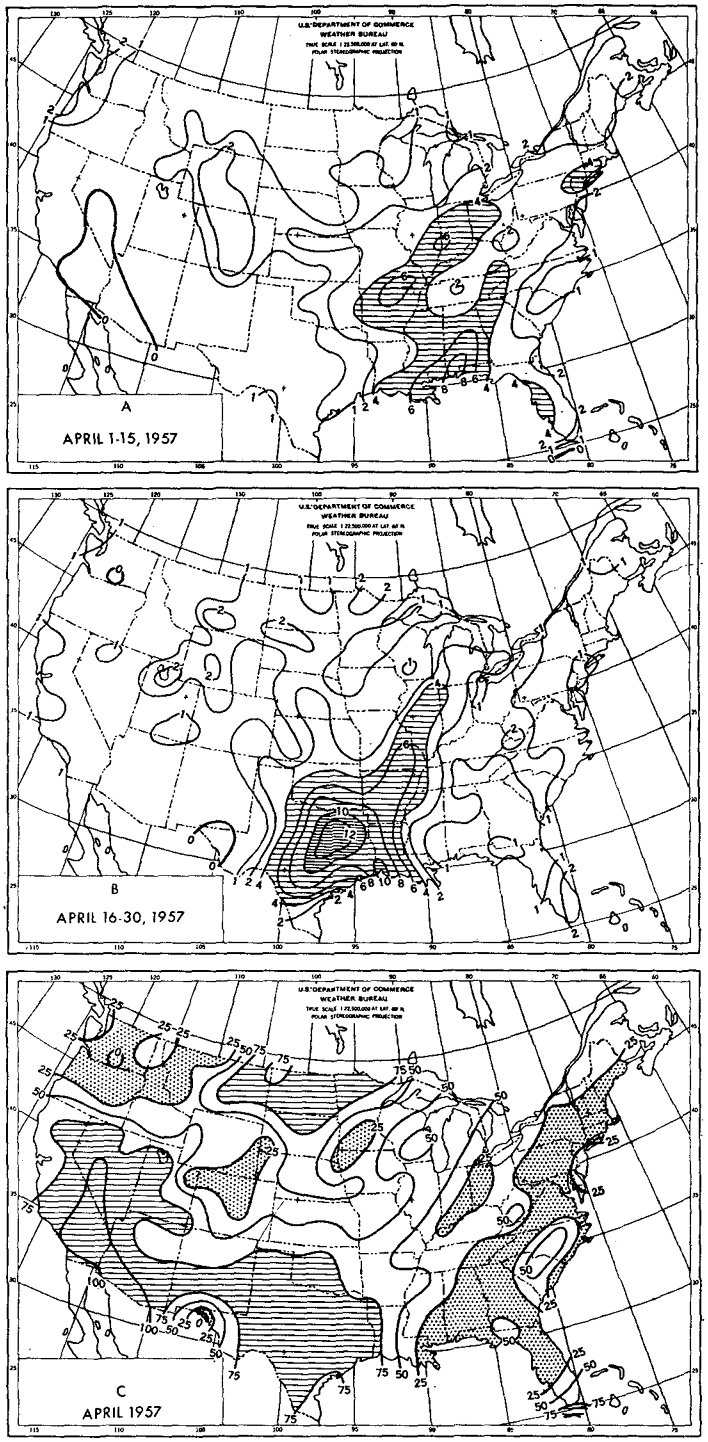


Figure 4.—Observed precipitation (approximate) in inches for (A) 1930 EST March 31 to 1930 EST April 15, 1957, and (B) 1930 EST April 15 to 1930 EST April 30, 1957. Areas with amounts greater than 4 inches are hatched. (C) Percentage (approximate) of the total April 1957 precipitation which fell during second half. Stippling indicates under 25 percent; hatching, over 75 percent.

eastward as southern Virginia. One of the worst of these storms swept across Dallas, Tex., on the 2d, causing some fatalities and much property damage. In addition, on this date there were 42 tornadoes and funnel clouds

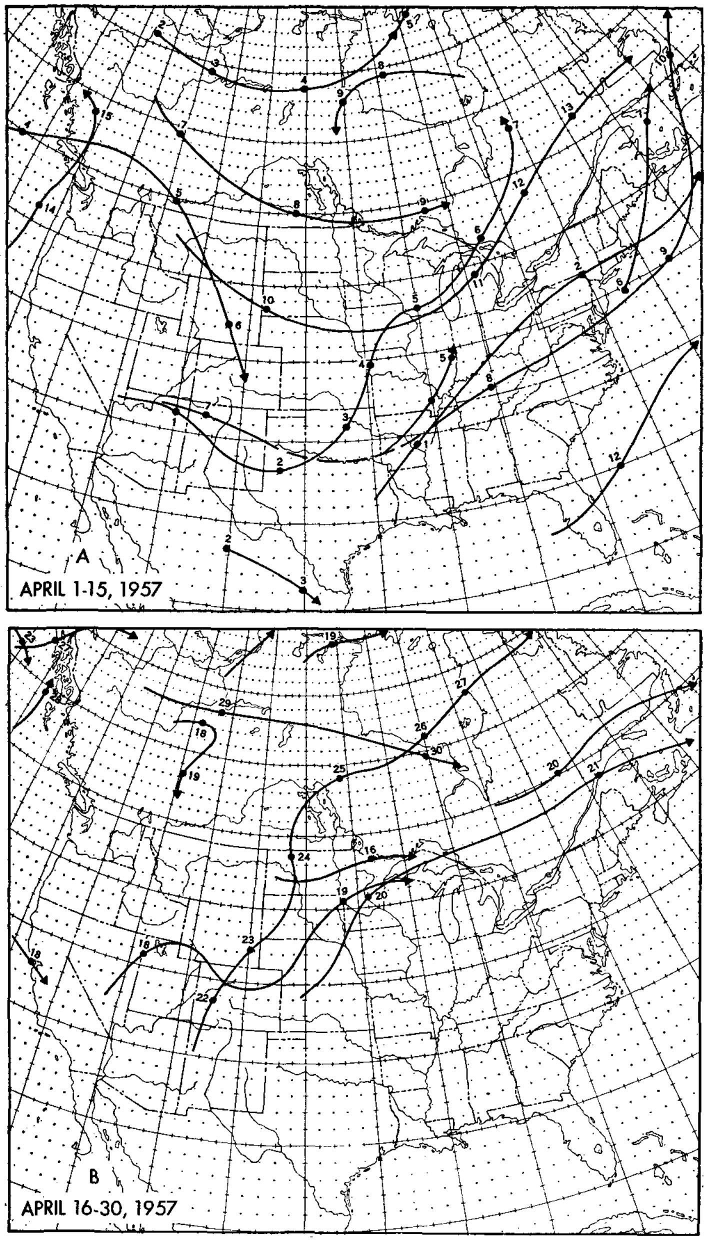


FIGURE 5.—Tracks of centers of cyclones at sea level for (A) Apr 1–15, and (B) April 16–30, 1957. Dots indicate position of center at 0730 EST. Dashed line in track indicates reformation at new position. Northward shift of storm tracks during the last half of the month was related to corresponding displacement of jet stream (fig. 2A) and to pronounced anticyclogenesis in the eastern United States (fig. 1).

reported in the United States, more than on any other day during the first half of the month.

A rather severe north Pacific coastal storm with wind gusts to 70 m. p. h. on the 14th brought heavy rains to that area, although much of the region's precipitation for the period was related to cold fronts associated with storm systems moving through British Columbia (figs. 4A and 5A).

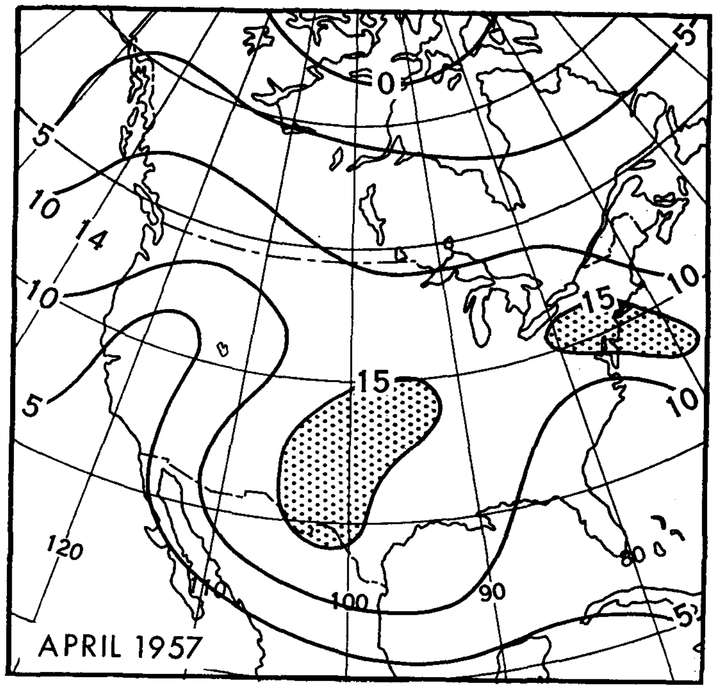


FIGURE 6.—Number of days in April 1957 with fronts of any type (within squares with sides approximately 430 nautical miles). Frontal positions taken from *Daily Weather Map*, 1330 EST. High frequency of fronts in the south-central United States was related to heavy rains and storminess in that area.

4. MID-APRIL CIRCULATION TRANSITION

The 15-day mean 700-mb. chart for April 16–30, 1957 (fig. 1B) shows the disappearance of the eastern Pacific trough that was present earlier in April. The resulting long wavelength was relieved when the United States trough retrograded by some 15° to 20° of longitude, while at the same time the western Pacific trough progressed a similar distance. This readjustment of the long-wave pattern was accompanied by increasing amplitude of the trough-ridge systems over the United States and the Atlantic.

Blocking was also present in varying intensity during the last half of April. The surge over Alaska earlier in the month continued to retrograde and can be identified with the +220-ft. height anomaly center over the Arctic Basin (fig. 1B). Only remnants of the Canadian block remained, identified by positive height anomalies in that area. In this connection it is difficult to ascribe any continuity to the +390-ft. height anomaly center in figure 1A. However, from a study of 5-day mean 700-mb. height anomaly charts, this center appears to have contributed very little to the +470-ft. center over the northeastern United States in figure 1B. This latter center, and its associated closed upper-level High, was largely the result of rapid dynamic anticyclogenesis. The early April block in the Atlantic was now farther south and amalgamated with the low-latitude ridge, while a new and intense block appeared over western Russia (fig. 1B). The latter block had an extensive upper-level anticyclone associated with

Table 1.—*Half-monthly mean zonal westerly values (m. p. s.) at 700 mb. for April 1957*

Index	Atlantic (5° W.-65° W.)				North America (65° W.-135° W.)				Pacific (135° W.-145° E.)			
	Apr. 1-15		Apr. 16-30		Apr. 1-15		Apr. 16-30		Apr. 1-15		Apr. 16-30	
	Observed	Departure from normal	Observed	Departure from normal	Observed	Departure from normal	Observed	Departure from normal	Observed	Departure from normal	Observed	Departure from normal
Polar (55° N.-70° N.)	0.8	−3.4	7.6	+3.4	0.6	−4.4	6.9	+1.9	1.8	+0.7	*−2.3	−3.4
Temperate (35° N.-55° N.)	8.7	+0.5	6.9	−1.3	7.7	+0.1	7.4	−0.2	10.0	+0.6	12.8	+3.4
Subtropical (20° N.-35° N.)	7.1	+0.8	4.2	−2.1	7.6	+1.3	2.7	−3.6	4.7	−1.5	2.5	−3.7

*Represents easterly flow.

it, along with a 700-mb. height anomaly center of +550 ft.

Perhaps this transition in the mean 700-mb. circulation at mid-month can best be seen by reference to figure 7, which shows the change in departure from normal of 700-mb. height (anomalous height change) from the first half of the month to the last half. The most striking features of this chart are: (1) The large falls in the eastern Aleutians, associated with retrogression of the Alaskan block toward the northwest; (2) the +520-ft. center over northeastern United States, related to anticyclogenesis in the east; and (3) the +700-ft. center over northwestern Russia, associated with the new block.

These changes in general circulation can also be related to regional changes in zonal index. In table 1 is given a list of the various indices at 700 mb. for each half of the month along with their departures from normal. Relaxation of blocking over Canada and the North Atlantic was accompanied by a sharp rise in the polar westerlies, a slight diminution in the zonal westerlies, and a considerable decrease in the strength of the subtropical westerlies. Amplification of the early April planetary waves over the United States and western Atlantic (fig. 1) was associated with a marked northward displacement of the mean jet stream axis (fig. 2A). Over the United States this transition from a zonal-type flow pattern to a more meridional type was accompanied by a pronounced change in weather regime.

5. LATE APRIL WEATHER IN THE UNITED STATES

THE "HEAT WAVE" AND INCREASING DROUGHT IN THE EAST

The unseasonable cold in the eastern two-thirds of the Nation early in April was replaced by unseasonable warmth over a vast area during the latter half of the month (fig. 3). From the Great Plains to the Middle Atlantic States the anomalous temperature change between the two halves of April was as much as +15° to +20° F.

A wide area from Minnesota to Virginia experienced average temperatures of 10° F. or more above normal, with Buffalo, N. Y., reporting a departure of +14° F. and an all-time record maximum temperature for April of 87° F. on the 24th. A similar record was established at Escanaba, Mich., with 82° F. on the 29th. In much of the area from the Lower Ohio Valley to Virginia the period April 20–28 [6] was the longest April "heat wave" ever recorded. At Richmond, Va., in spite of subnormal temperatures during the first half of the month, this was the warmest April during 60 years of record.

By way of contrast, temperatures west of the Divide were mostly subnormal with departures of −6° F. in the Southern Plateau.

Precipitation was markedly deficient during the period April 16–30, 1957, over the eastern third of the Nation and in portions of the Upper Mississippi Valley. In much of this area less than one-fourth of the total precipitation for the month was observed during the last half, and as little as one-tenth in many sections from New England to Florida (fig. 4C). At Albany, N. Y., a record dry spell for the month of April was established when no measurable precipitation fell during the 17-day period from the 13th through the 29th. This was the driest April of record for much of the eastern Carolinas, Wilmington, N. C., receiving only 0.33 inches of precipitation (records date back to 1871).

The combination of abnormal warmth and insufficient precipitation led to drought in the East. As the dry spell lengthened, the forest fire hazard increased, particularly in New England where a rash of fires broke out.

The abrupt reversal from a cold, relatively wet regime to a warm, dry pattern was associated with growth of the mid-tropospheric anticyclone which was centered over the Carolinas (fig. 1B). An inspection of daily 700-mb. charts reveals that this warm cell became firmly established over the Carolinas shortly after mid-month. The circulation around this High affected the weather pattern from the Divide to the Atlantic Coast. Note how well the temperature anomaly pattern corresponds to the 700-mb. height departure from normal field (figs. 3B and 1B) in the usual relationship [5]. Anticyclonic curvature and wind shear, associated with large-scale subsidence, can be related to the dry regime in the East. In addition the mean westerly jet axis and associated storm tracks shifted far northward, leaving the East completely free of any migratory cyclonic activity (figs. 2A and 5).

Over the Northern Plains, California, and the central and southern Plateau States most of April's precipitation fell during the latter half of the month (fig. 4C). Much of this was related to two short-wave troughs moving through the mean ridge off the Pacific Coast, and to subsequent marked surface development occurring as these troughs moved into the mean trough in the West (figs. 5B and 1B). Locally heavy amounts were observed, and a 24-hour fall of 2.41 inches at Salt Lake City, Utah on April 22–23 broke a 28-year record.

THE TEXAS FLOODS AND SUBSTANTIAL DROUGHT RELIEF IN THE SOUTHWEST

The trend toward increasing rainfall since the beginning of the year in the drought area of the Southwest continued during the latter half of April, when record and near-record amounts of rain fell from central Texas to Illinois, with excessive amounts in central and eastern Texas. In the southern and central Plains States severe weather, in the form of tornadoes, thunderstorms, hail, and heavy rain showers, was a frequent occurrence. This activity occasionally extended into the middle Mississippi Valley and the Great Lakes region. In table 2 is shown a representative list of cities in the heavy rain belt of April 1957 with their monthly precipitation totals, percentage of normal, and appropriate remarks. It is noteworthy that more than 90 percent of the Texas rains fell during the second half of the month (fig. 4). These seemingly incessant rains culminated in extensive flooding late in the month. Quoting from the April 29, 1957 issue of the *Weekly Weather and Crop Bulletin, National Summary* [11],

> Following a long period of drought, east and central Texas received excessive amounts of rainfall, filling reservoirs and causing widespread flooding. Beginning April 18, heavy rains have been a daily occurrence in the area. Waco, Texas reported a total in excess of 13 inches during the period. However, some areas received as much as 7 inches in less than 24 hours. Serious flooding has developed in such major streams in Texas as the Sabine, Trinity, Brazos, Colorado, Guadalupe, and Nueces Rivers. Light to moderate flooding was reported in eastern Oklahoma and southwestern Arkansas.

Synoptically, conditions were highly favorable for the development and persistence of such severe weather. At 700 mb. this storminess can be related to the large-amplitude trough-ridge system in the United States and to the concomitant height anomaly pattern (fig. 1B). Vast quantities of moist tropical air were advected by strong south-southeasterly anomalous flow components at 700 mb. from the Gulf of Mexico into the Southern Plains. Here this moisture was released as a result of rising motion in a quasi-stationary frontal zone (fig. 6) between cold Pacific air to the west and warm tropical

TABLE 2.—*Selected precipitation records established during April 1957*

Station	Precipitation (inches)	Percent of normal	Remarks
Del Rio, Tex.	6.49	447	April record.
Dallas, Tex.	13.85	358	Do.
Fort Smith, Ark.	10.32	230	Do.
Wichita Falls, Tex.	8.50	361	Do.
Shreveport, La.	11.19	244	Do.
San Antonio, Tex.	9.32	308	2d wettest April.
Fort Wayne, Ind.	7.11	219	Do.
Springfield, Ill.	8.86	259	Greatest since 1893.
Little Rock, Ark.	11.34	220	Greatest since 1927.
Lake Charles, La.	13.71	321	Greatest since 1940.
Waco, Tex.	13.37	337	

428956—57——2

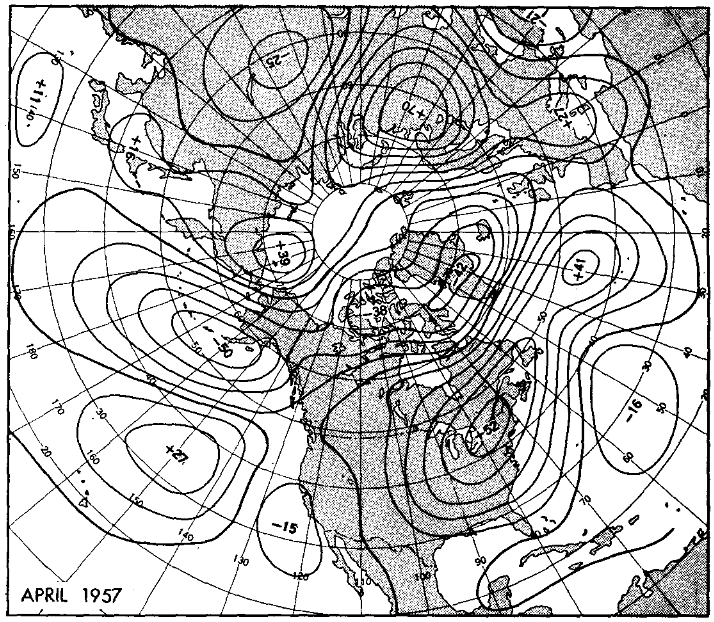


FIGURE 7.—Mean 700-mb. anomalous height change (in tens of feet) from April 1–15 to April 16–30, 1957. Areas of large change were associated with marked reversal of the planetary circulation.

air to the east (fig. 3B). It is noteworthy that the heaviest rains fell under cyclonic southwesterly flow at 700 mb. about halfway between trough and ridge, the optimum place for heavy precipitation and upward vertical motion according to Klein [4]. The 700-mb. departure from normal height pattern (fig. 1B) associated with these rains is also quite similar to the results of Martin and Hawkins [5] and Stidd [9] in later precipitation studies. Stidd, by use of correlation fields relating mean monthly 700-mb. height and monthly precipitation averaged over a given State, found that for Texas (and Arkansas) the heaviest rains occurred when pressures were above normal in the East and below normal in the Southwest. Martin and Hawkins obtained similar results by relating the 10 wettest 5-day mean periods at Fort Worth, Tex. to their corresponding 700-mb. height and height anomaly fields. It must be noted, however, that all these studies related to winter cases, so that their applicability to spring may be questioned.

The meridional circulation pattern in the United States (fig. 1B) resulted in a strong surface thermal gradient from Texas to the northern Rockies (fig. 3B), with a resultant high frequency of surface fronts in the central and southern Plains States (fig. 6). Advection of cold maritime Pacific airmasses into and through the mean trough, replacing and lifting warm tropical airmasses, triggered much of the violent weather. Many of the tornadoes in the Plains States were of the "cyclonic type" and were associated with cold fronts and squall lines southeast of the migratory cyclonic centers (fig. 5B). More tornadoes

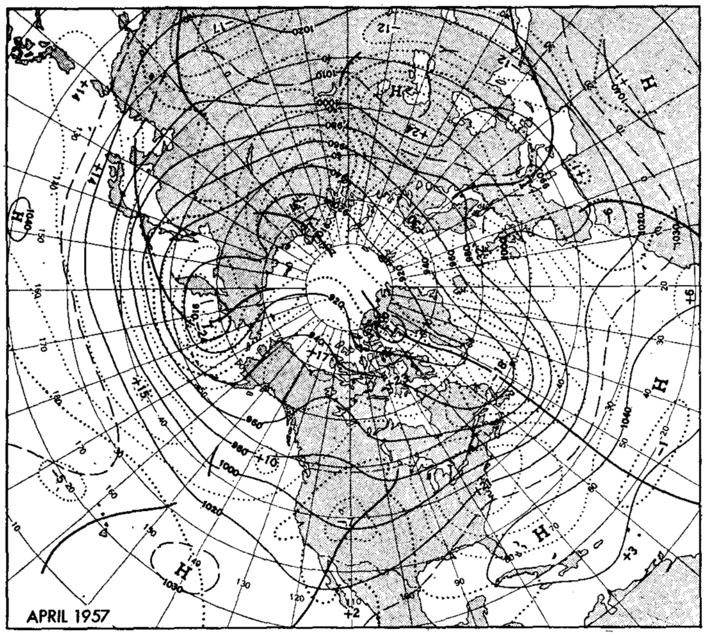


Figure 8.—Mean 700-mb. height contours (solid lines) and departures from normal (dashed lines) (both in tens of feet) for April 1–30, 1957. Major circulation features over North America were the trough-ridge system in the United States and blocking across Canada.

and funnel clouds (53) were observed on the 22d than on any other day of April. Late in the month, when high pressure covered most of the United States and cyclonic activity was at a minimum (fig. 5B), the tornadoes in the Southern Plains were of the "convective type" and were associated mainly with weak surface pressure troughs.

While heavy rains and floods occurred in central and eastern Texas, little if any precipitation fell in the southwestern portion of that State (fig. 4), and the drought there continued. This deficiency of precipitation can probably be related to downslope motion in greater than normal southwesterly flow aloft (fig. 1B).

6. MONTHLY SUMMARY

As might be expected, the mean monthly 700-mb. chart for April (fig. 8) displays many of the features present on the half-monthly mean charts (fig. 1). However, the disappearance of the full-latitude eastern Pacific trough from the first half to the last half of April is reflected on the monthly chart as only a minor mid-latitude trough. The result is a rather long wave spacing between the Asiatic coastal trough and the United States trough. In view of the transition in circulation that occurred near mid-month, such a long wavelength is quite reasonable.

Monthly mean wind speeds at 700 mb. were strongest across the Atlantic and over the western Pacific, where speeds were 7 m. p. s. above normal (fig. 2B). At sea level this strong westerly flow was associated with deeper than normal Aleutian and Icelandic centers of action, the former being 11 mb. below normal while the latter averaged 9 mb. below the April normal (Chart XI).

Table 3.—*Tornadoes and funnel clouds observed in the United States during April 1957 (preliminary figures)*

Period	Tornadoes	Funnel clouds (not reaching the ground)	Total
Apr. 1–15	102	26	128
Apr. 16–30	135	133	268
April 1957	237	159	396

The monthly temperature and precipitation patterns (Charts I–B, II, and III) bear a normal relationship to the monthly 700-mb. height pattern and anomaly field (fig. 8) in a manner discussed previously for the half-monthly patterns. Especially important was the prevalence of southeasterly anomalous flow at sea level (Chart XI, inset) in the eastern half of the United States. This flow imported large quantities of Gulf moisture northward, where it later was released in varying amounts of precipitation from the Divide to the Atlantic Coast.

Both the monthly mean 700-mb. and sea level charts (fig. 8 and Chart XI) are strikingly similar to Beebe's composite charts for tornado occurrence for the central and southern Plains States [1], the area of most severe storminess during April 1957. In table 3 is given a summary of the number of tornadoes and funnel clouds which were observed in the United States during the month. Exclusive of the latter, the total of 237 tornadoes reported is an all-time April record, and more than double the previous record of 114 in April 1956 [2]. Much of this pronounced increase can be attributed to marked differences in the general circulation between the two Aprils. Similarly, the sharp increase in tornadic activity from the first half to the last half of this April was related to the transition in circulation which occurred at mid-month, as discussed in section 4.

Soil moisture in the Southwest now extends deeper than it has for five years, but it will take considerable time to rebuild the underground water storage. Although it is not possible to predict with complete confidence the break of the long-period drought, the trend established by the large-scale general circulation patterns this year offers hope that it is over. And although there was much damage from floods and violent weather, the benefits to agriculture can hardly be overestimated.

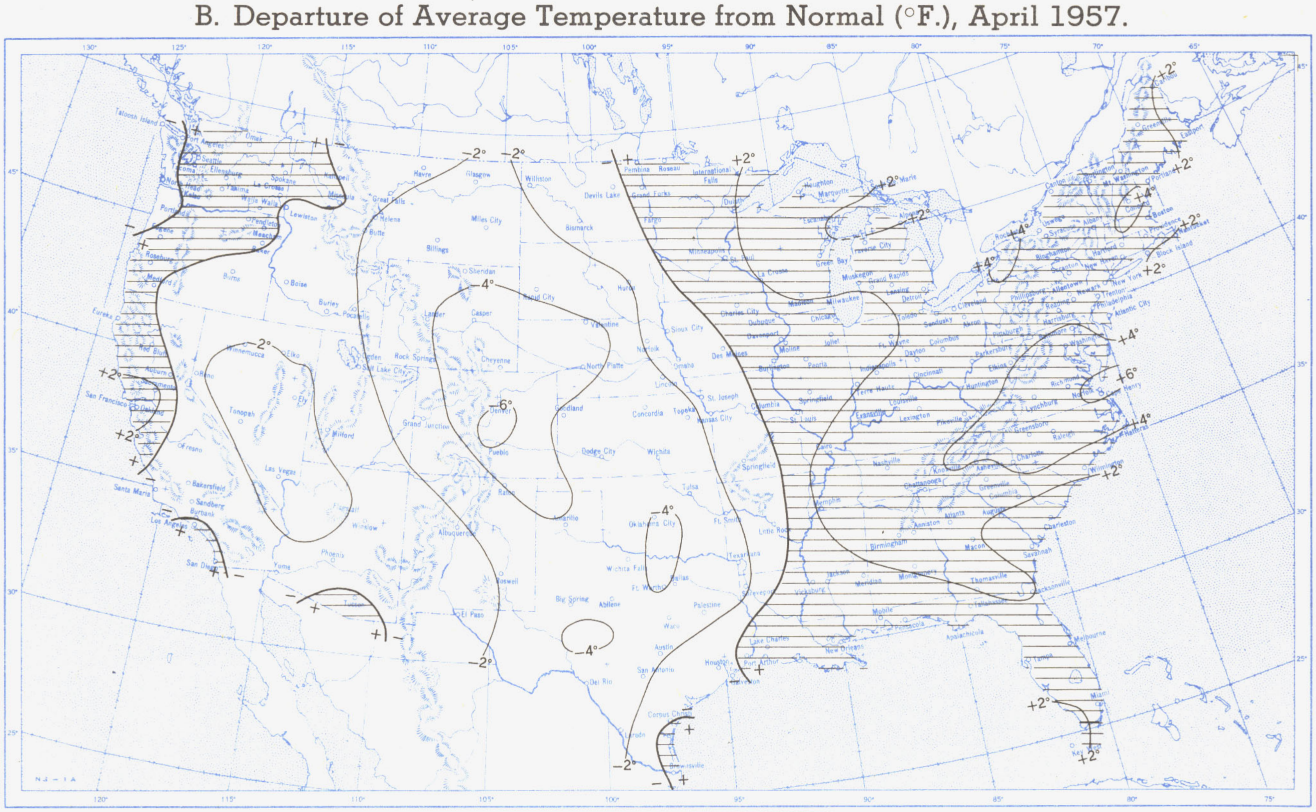
REFERENCES

1. R. G. Beebe, "Tornado Composite Charts," *Monthly Weather Review*, vol. 84, No. 4, Apr. 1956, pp. 127–142.
2. C. R. Dunn, "The Weather and Circulation of April 1956—A Cold Month With a Retrograding Blocking Surge," *Monthly Weather Review*, vol. 84, No. 4, Apr. 1956, pp. 146–154.
3. H. M. Frazier, "The Weather and Circulation of March 1957—A Month With an Extensive Polar Block and Expanded Circumpolar Vortex," *Monthly Weather Review*, vol. 85, No. 3, Mar. 1957 pp. 89–98.

4. W. H. Klein, "An Objective Method of Forecasting Five-Day Precipitation for the Tennessee Valley," U. S. Weather Bureau *Research Paper No. 29*, Apr. 1949, 60 pp.
5. D. E. Martin and H. F. Hawkins, Jr., "Forecasting the Weather—The Relationship of Temperature and Precipitation Over the United States to the Circulation Aloft," *Weatherwise*, vol. 3, Nos. 1–6, 1950.
6. H. R. McQueen and C. Pope, Jr., "The Eastern States Heat Wave of April 20–28, 1957," *Monthly Weather Review*, vol. 85, No. 4, Apr. 1957, pp. 132–139.
7. J. Namias, *Extended Forecasting by Mean Circulation Methods*, U. S. Weather Bureau, Feb. 1947. (See pp. 19–20.)
8. J. Namias, "Thirty-Day Forecasting: A Review of a Ten-Year Experiment," *Meteorological Monographs*, vol. 2, No. 6, American Meteorological Society, July 1953. (See pp. 19–26.)
9. C. K. Stidd, "The Use of Correlation Fields in Relating Precipitation to Circulation," *Journal of Meteorology*, vol. 11, No. 3, June 1954, pp. 202–213.
10. U. S. Weather Bureau, "Normal Weather Charts for the Northern Hemisphere," *Technical Paper* No. 21, 1952, 74 pp.
11. U. S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIV, No. 17, Apr. 29, 1957.

Chart I. A. Average Temperature (°F.) at Surface, April 1957.

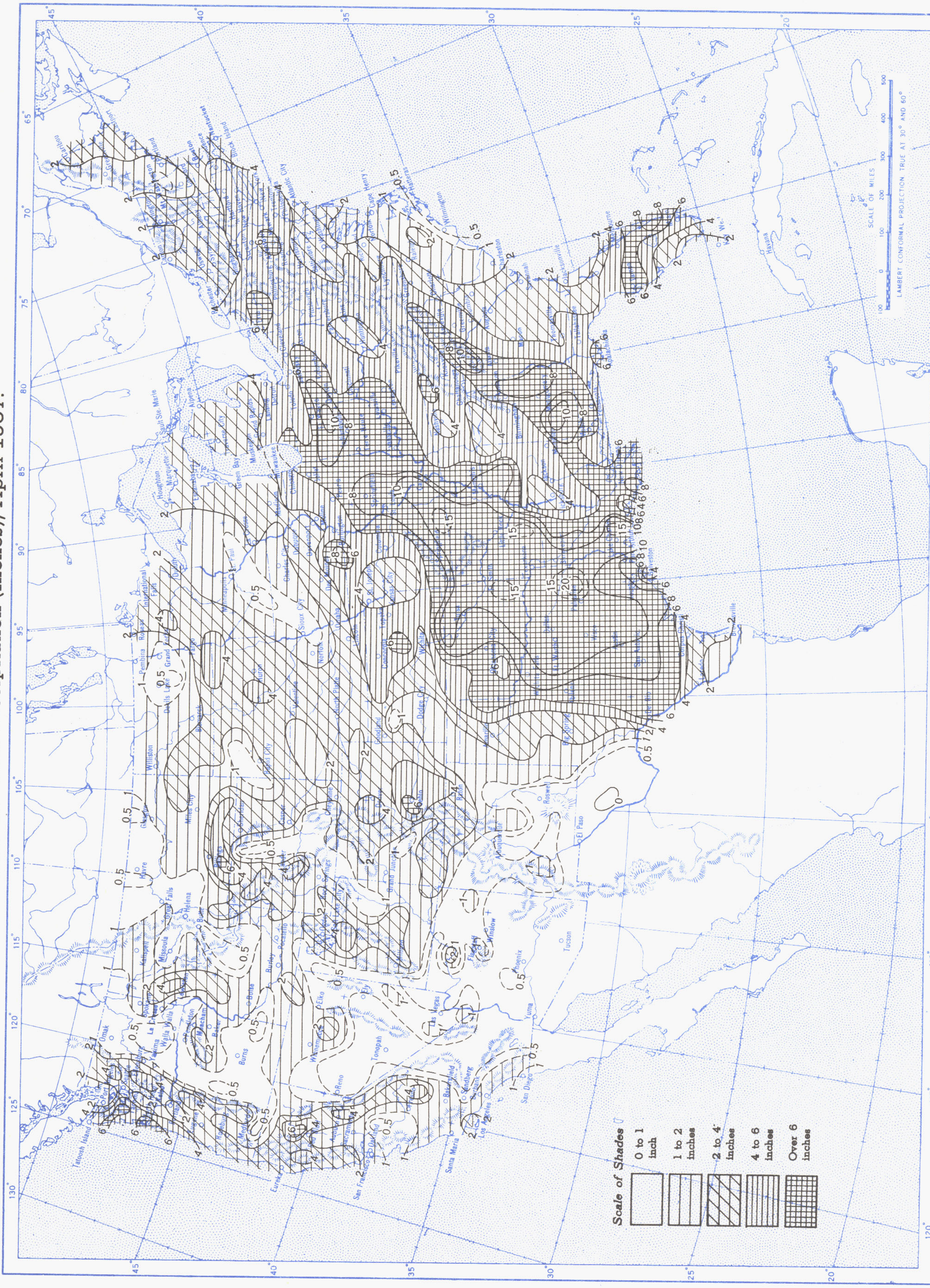
B. Departure of Average Temperature from Normal (°F.), April 1957.



A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.

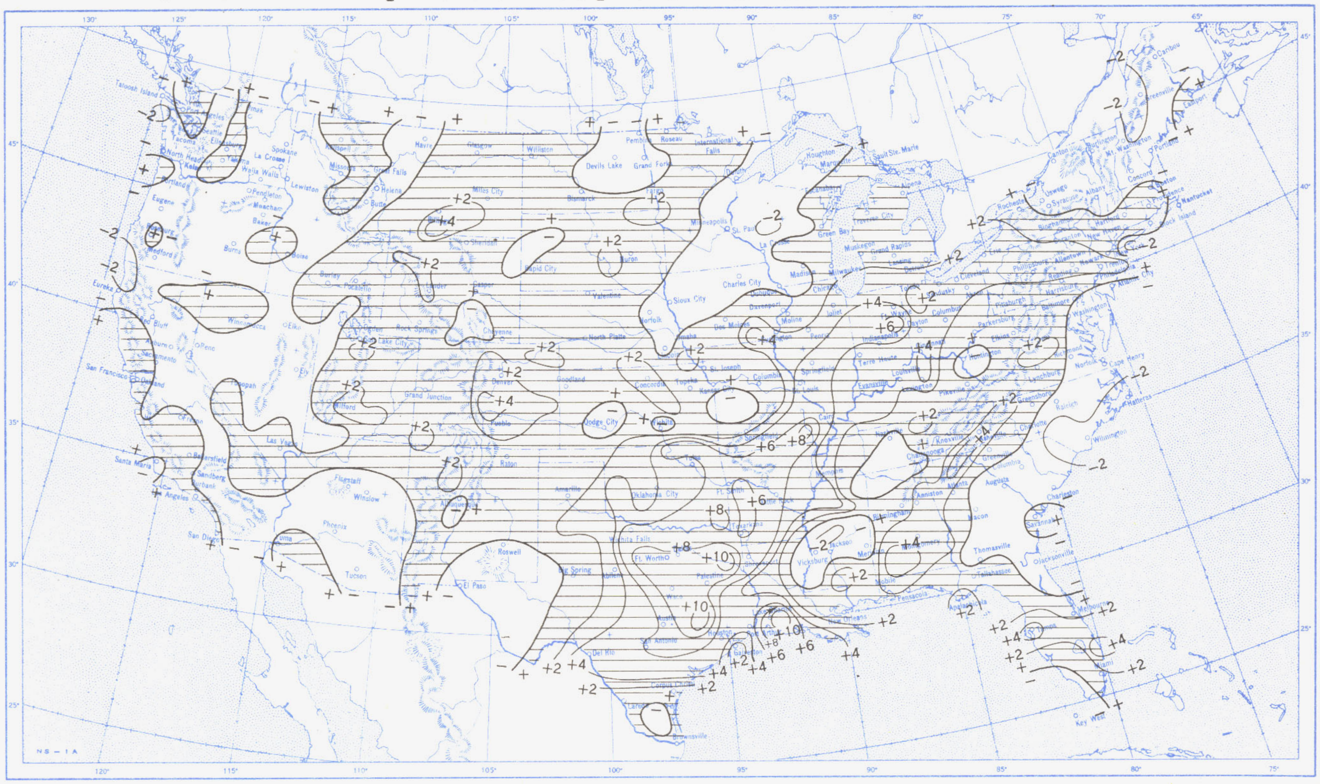
B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

Chart II. Total Precipitation (Inches), April 1957.

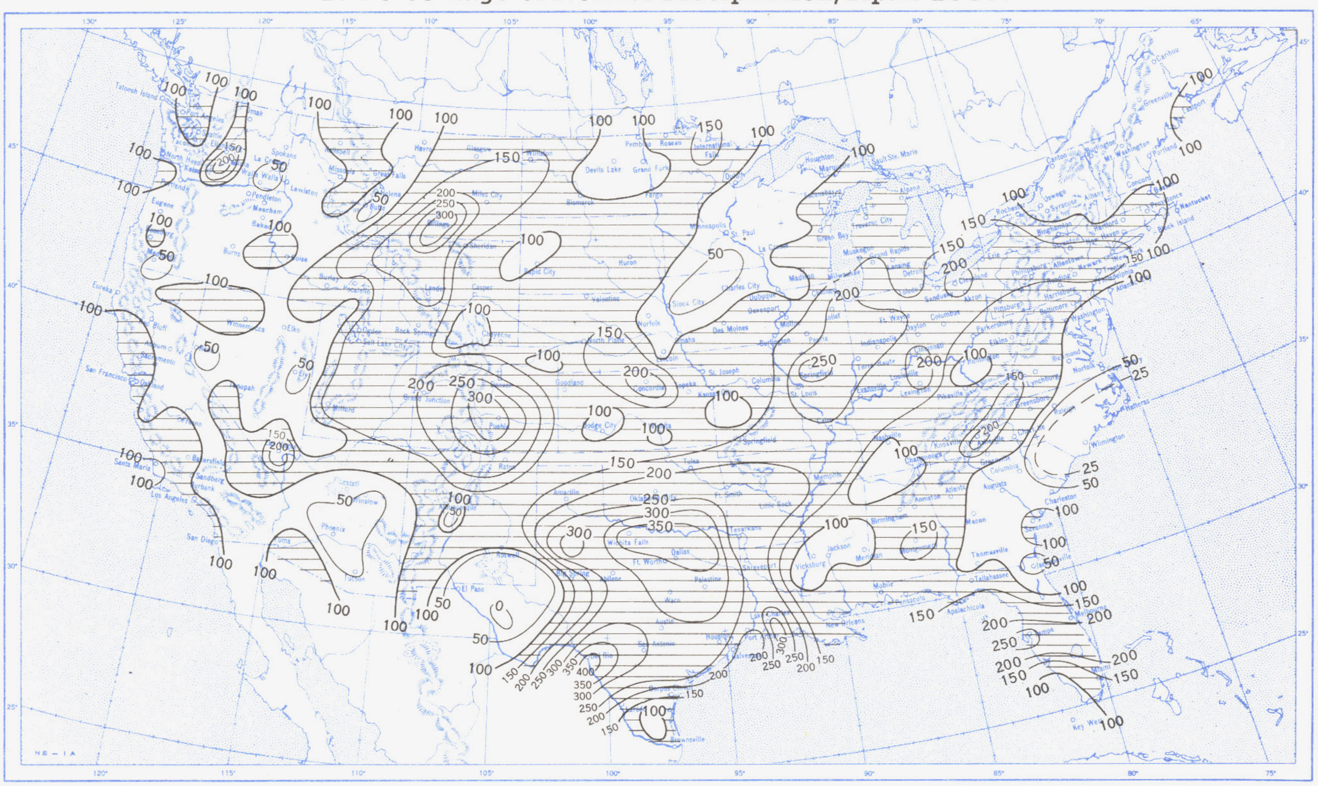


Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), April 1957.

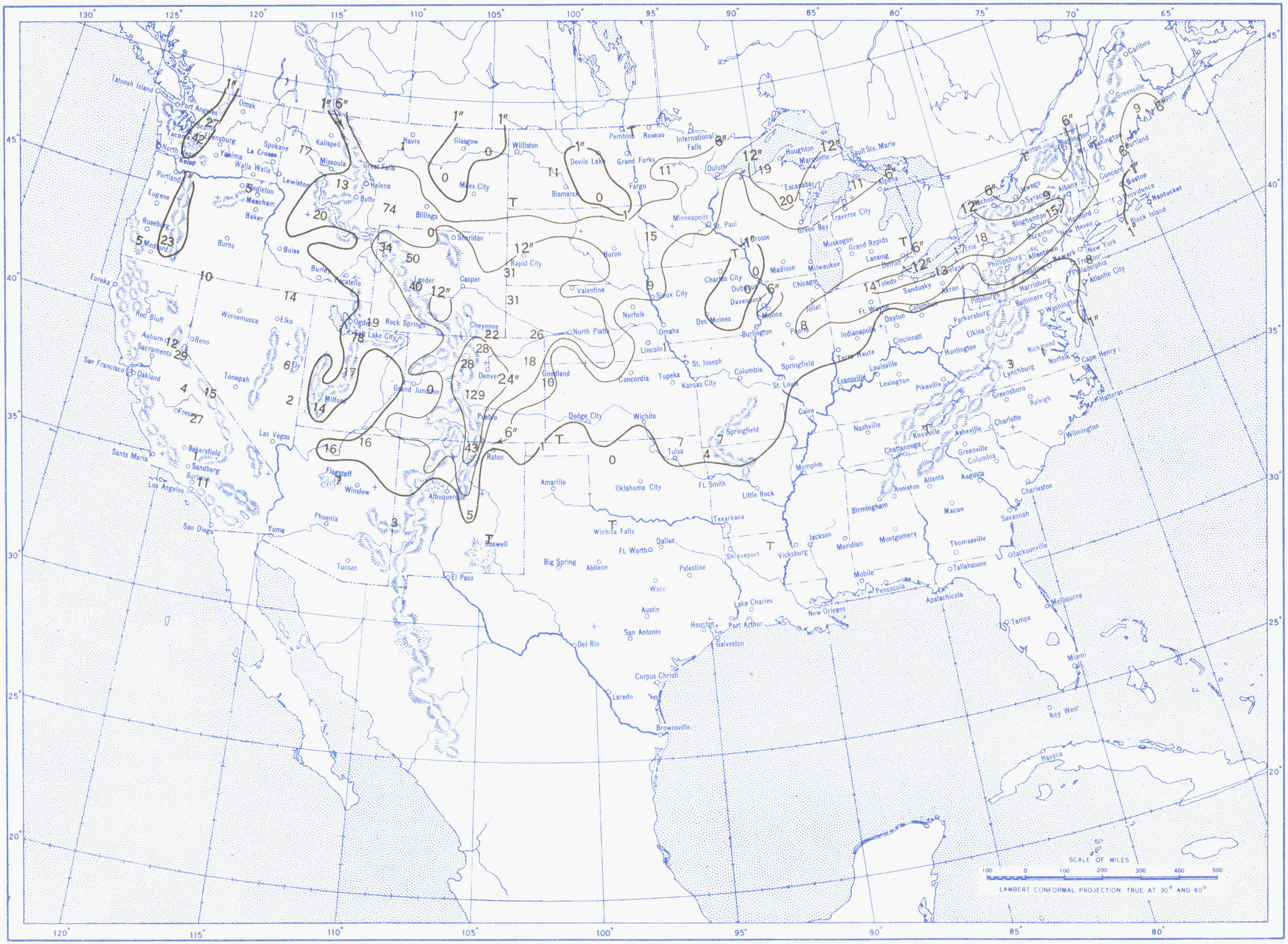


B. Percentage of Normal Precipitation, April 1957.



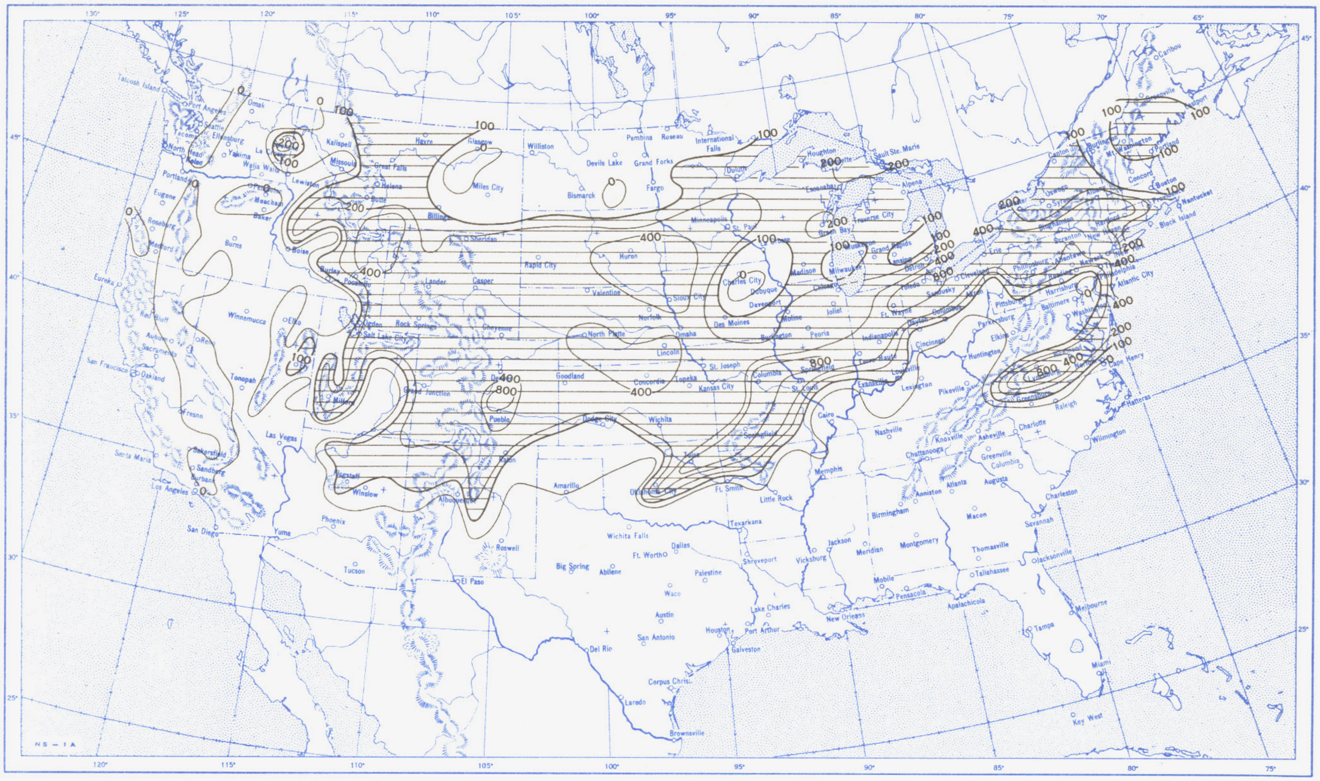
Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

Chart IV. Total Snowfall (Inches), April 1957.



This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

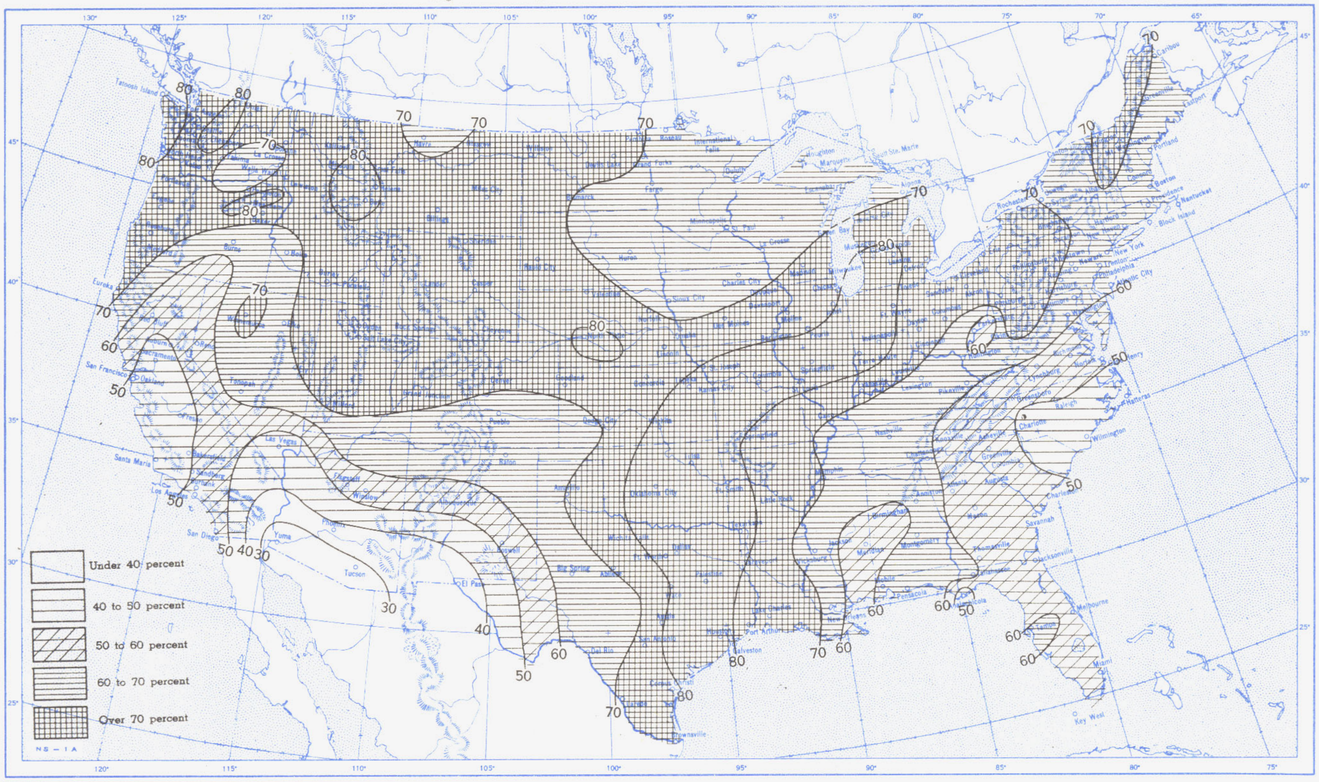
Chart V. A. Percentage of Normal Snowfall, April 1957.



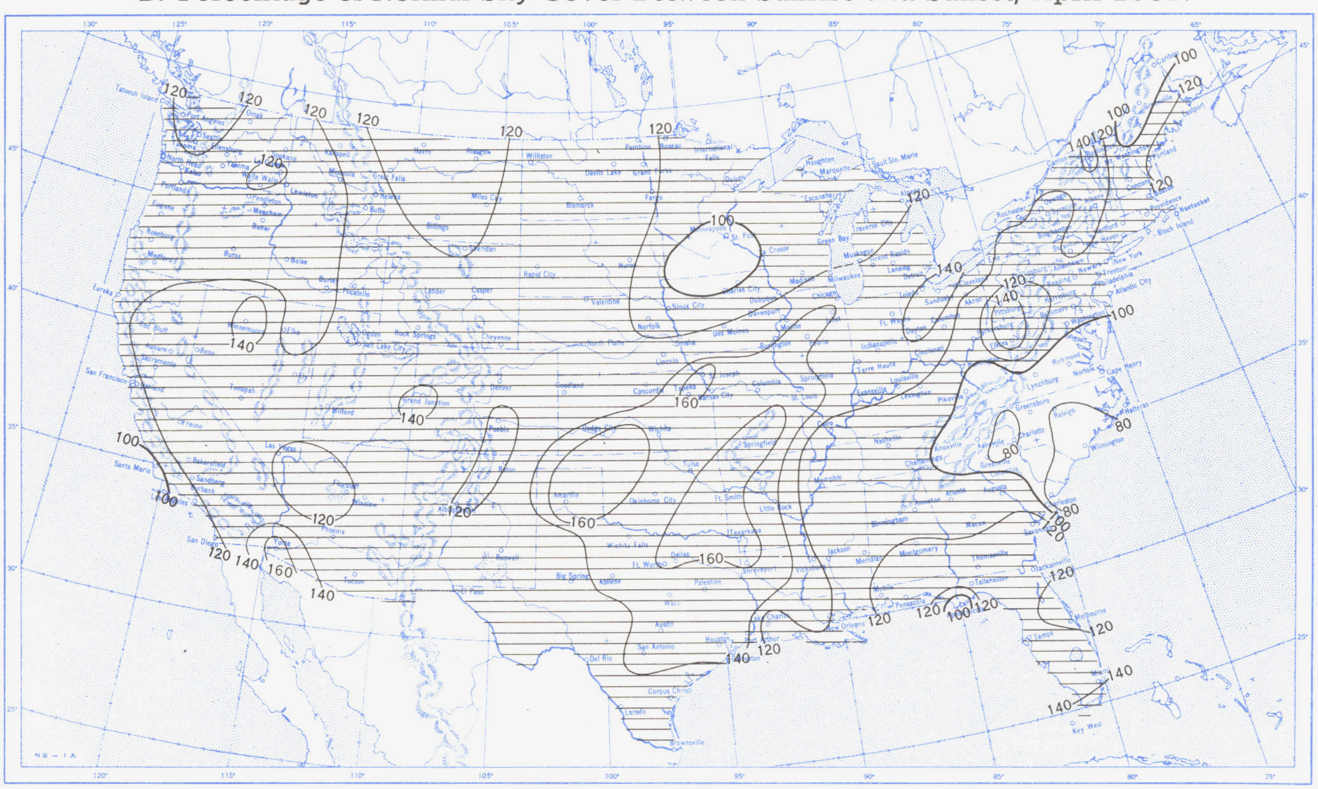
B. Depth of Snow on Ground (Inches). 7:30 a. m. E. S. T., April 29, 1957.

A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record.
B. Shows depth currently on ground at 7:30 a. m. E.S.T., of the Monday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, April 1957.



B. Percentage of Normal Sky Cover Between Sunrise and Sunset, April 1957.



A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, April 1957. Inset: Percentage of Mean Daily Solar Radiation, April 1957. (Mean based on period 1951-55.)

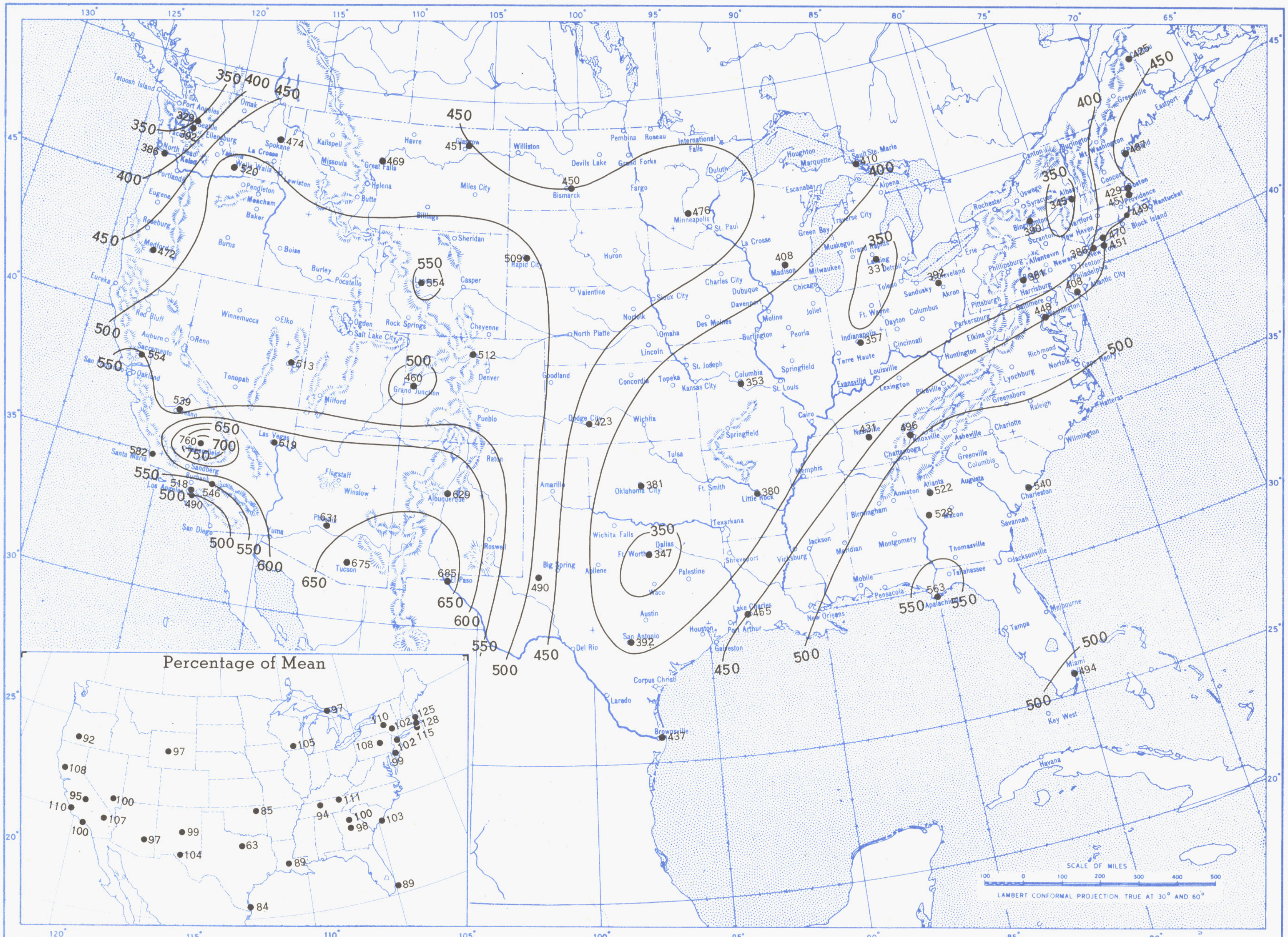
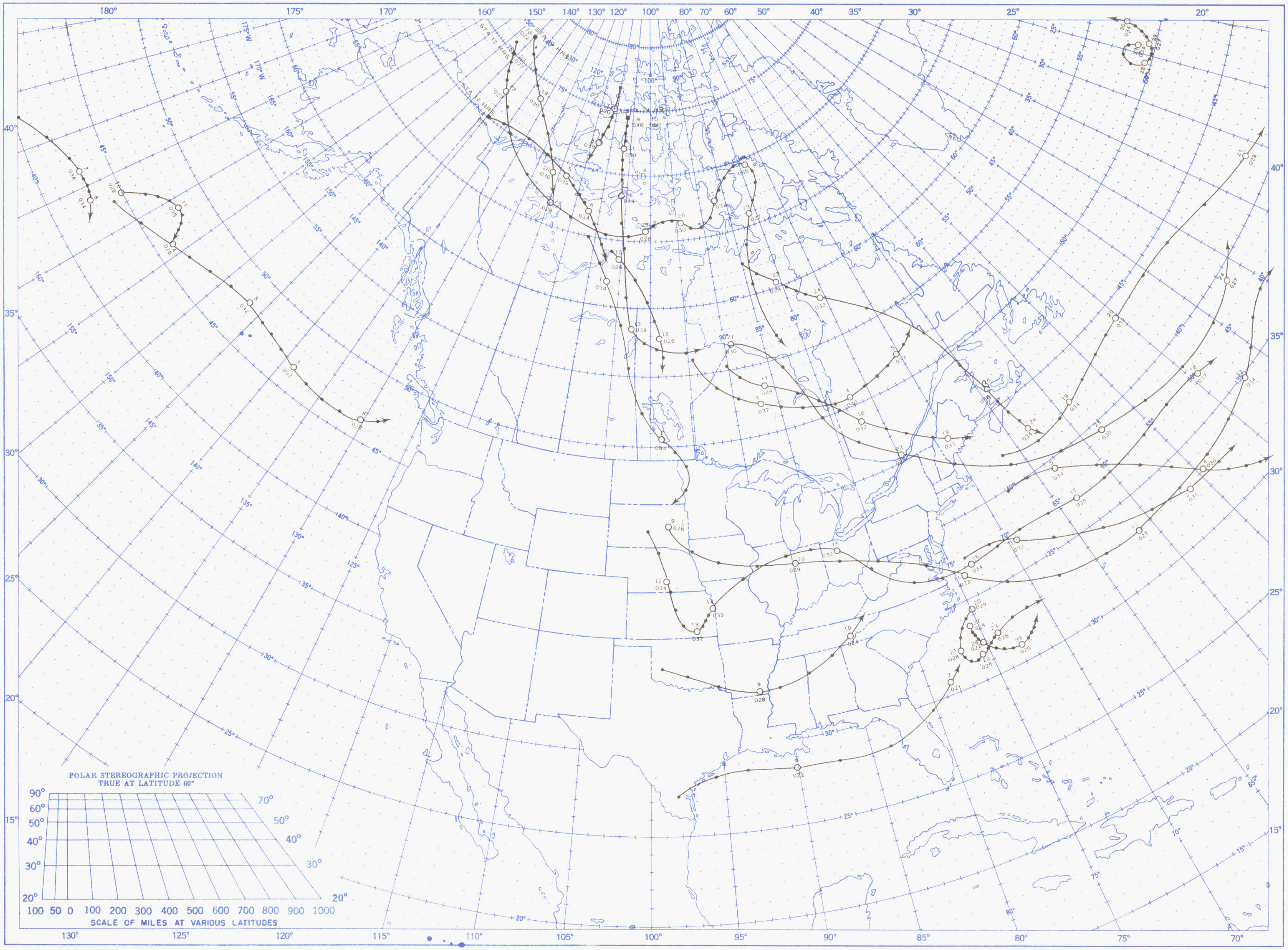


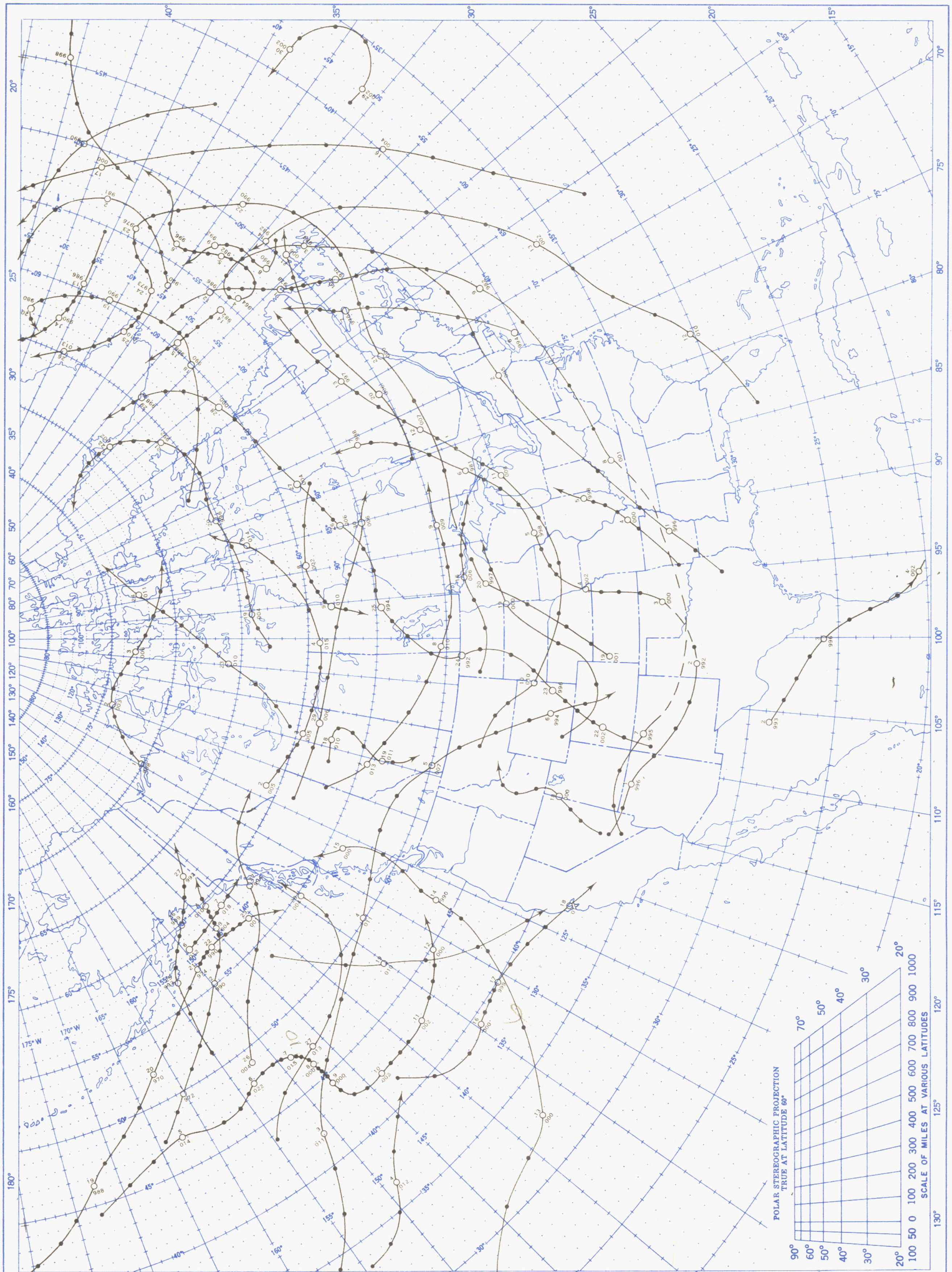
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, April 1957.



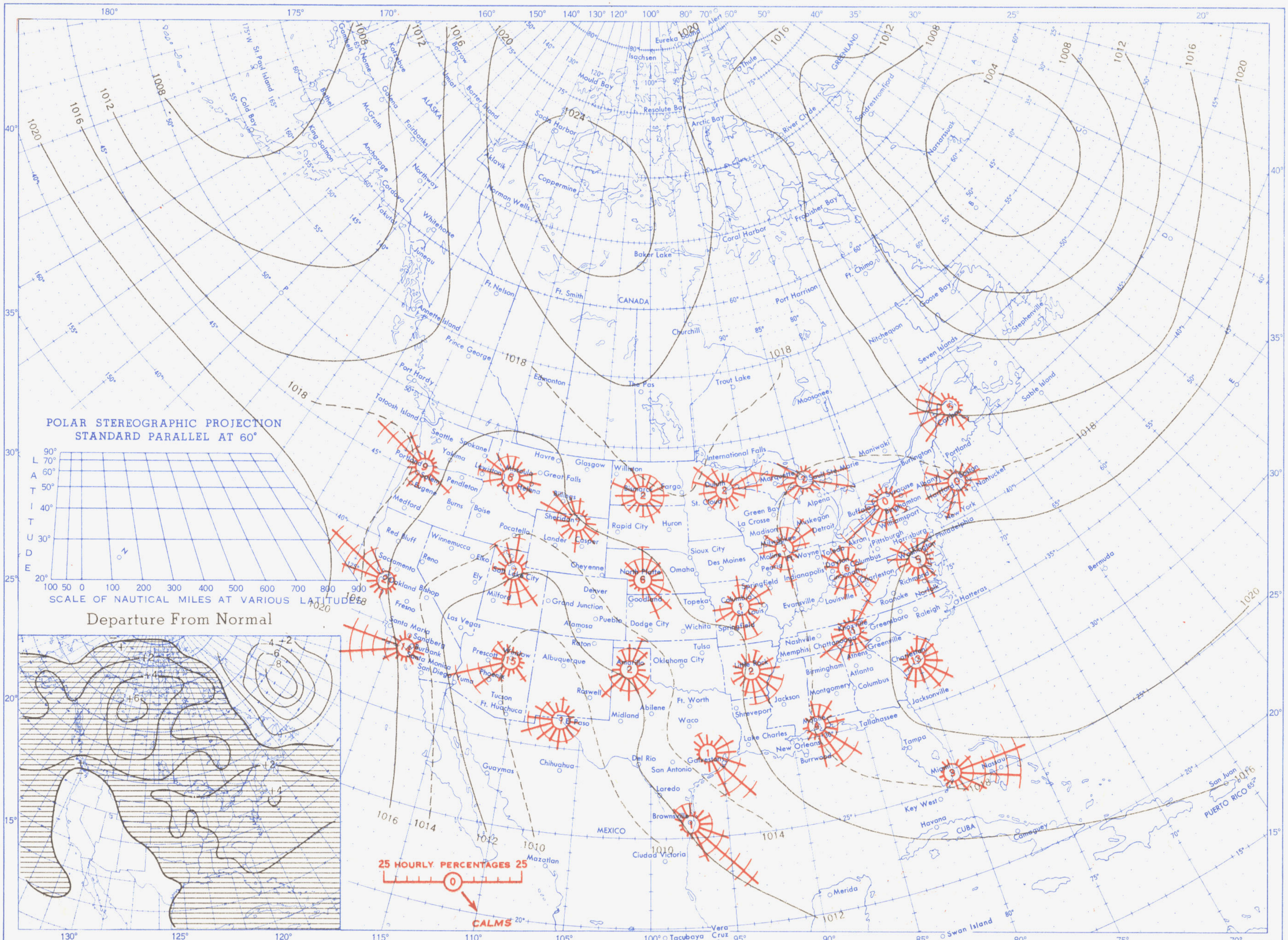
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, April 1957.



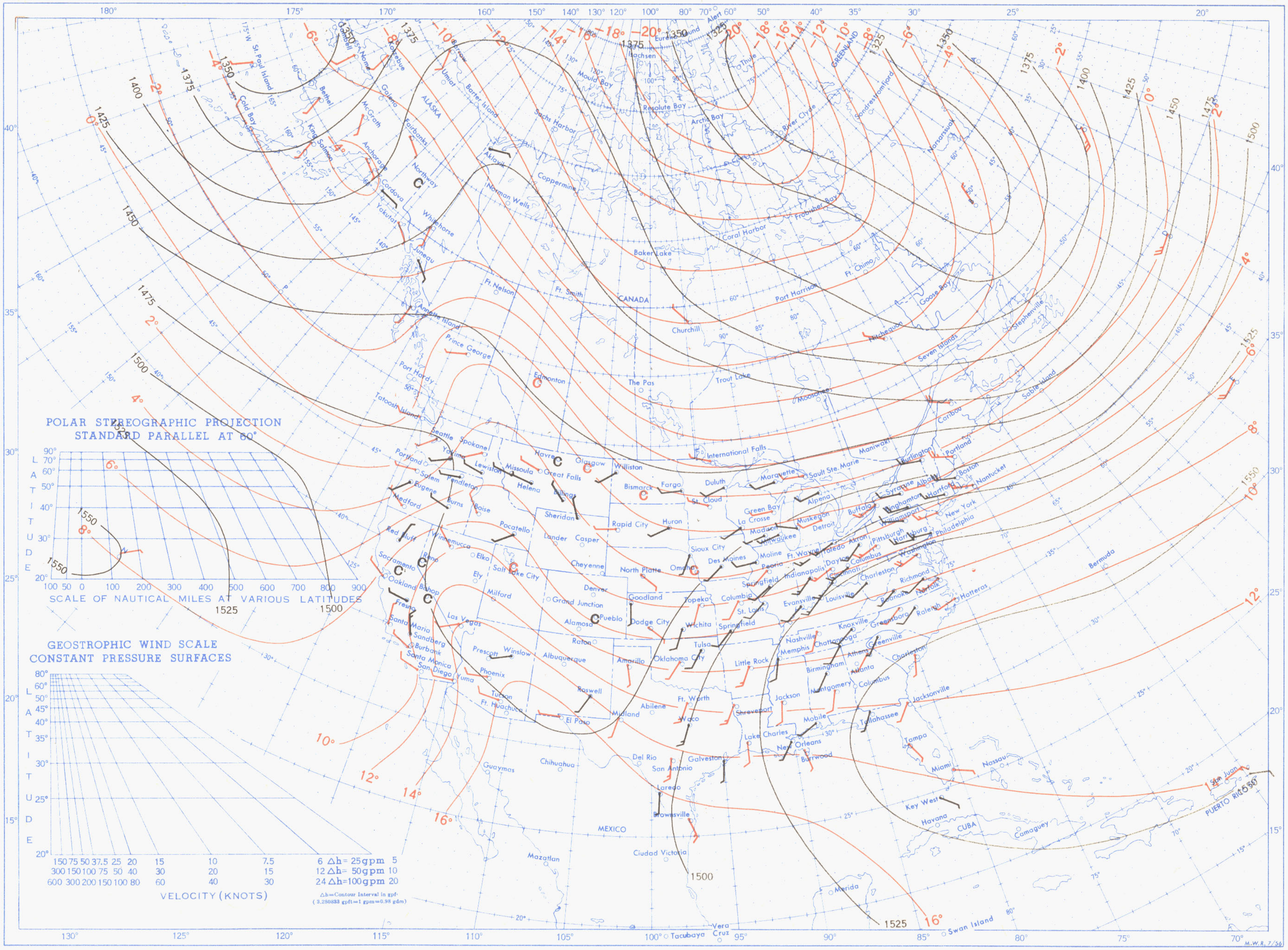
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, April 1957. Inset: Departure of Average Pressure (mb.) from Normal, April 1957.



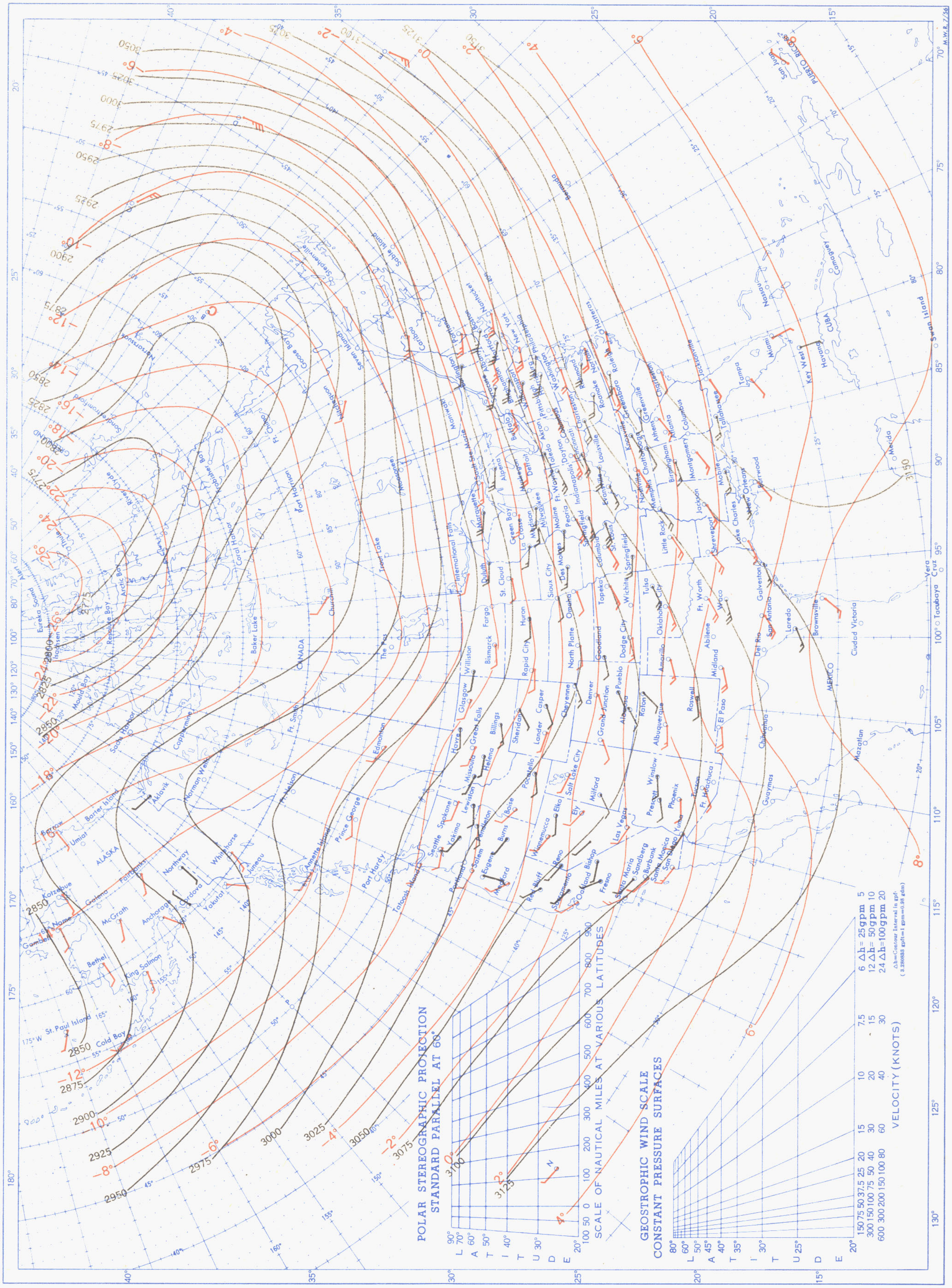
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 0300 GMT, April 1957. Average Height and Temperature, and Resultant Winds.



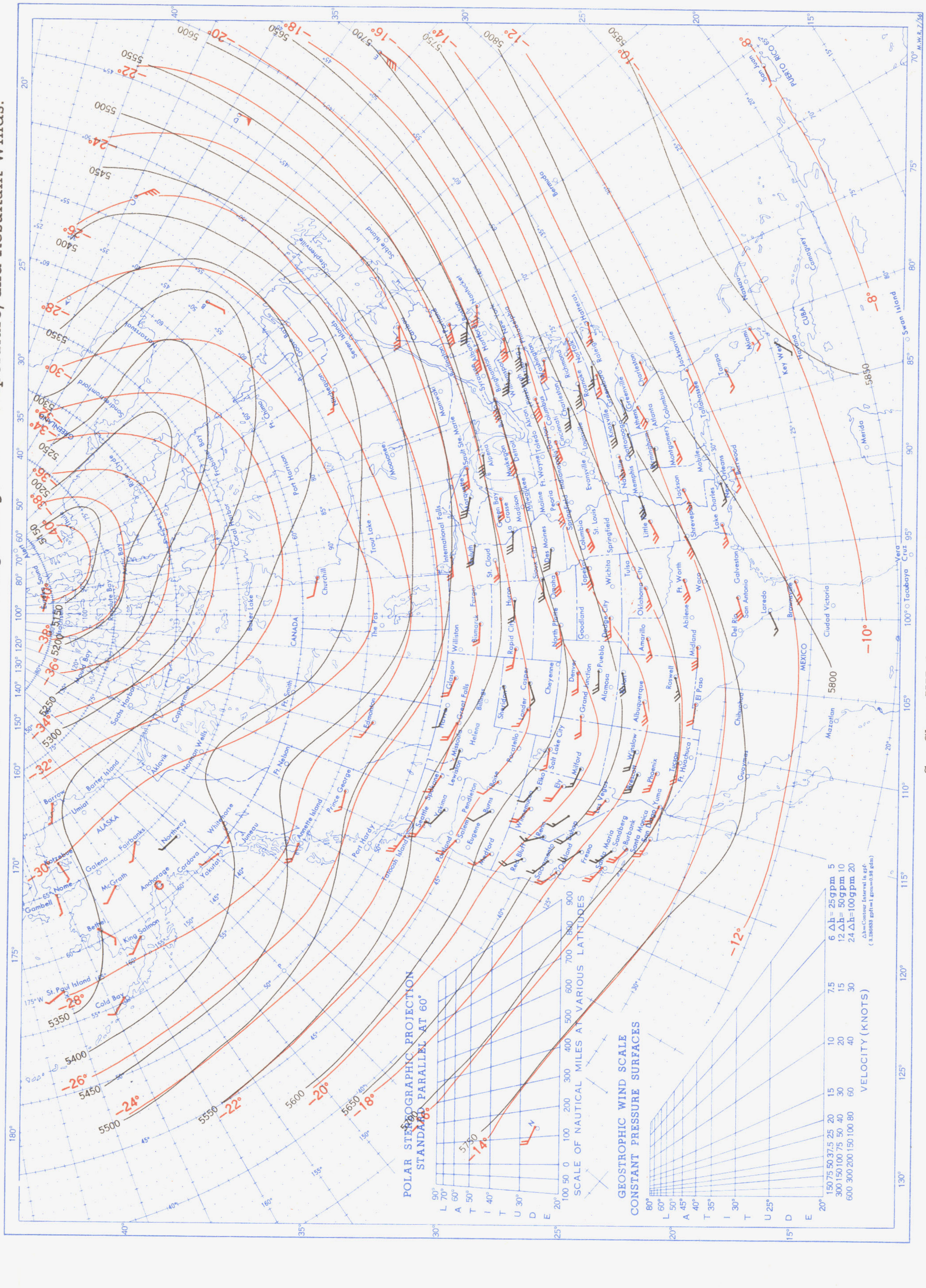
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. Winds shown in red are based on rawins taken at the indicated pressure surface and time. Those in black are based on pibals taken at 2100 GMT and are for the nearest standard height level.

Chart XIII. 700-mb. Surface, 0300 GMT, April 1957. Average Height and Temperature, and Resultant Winds.



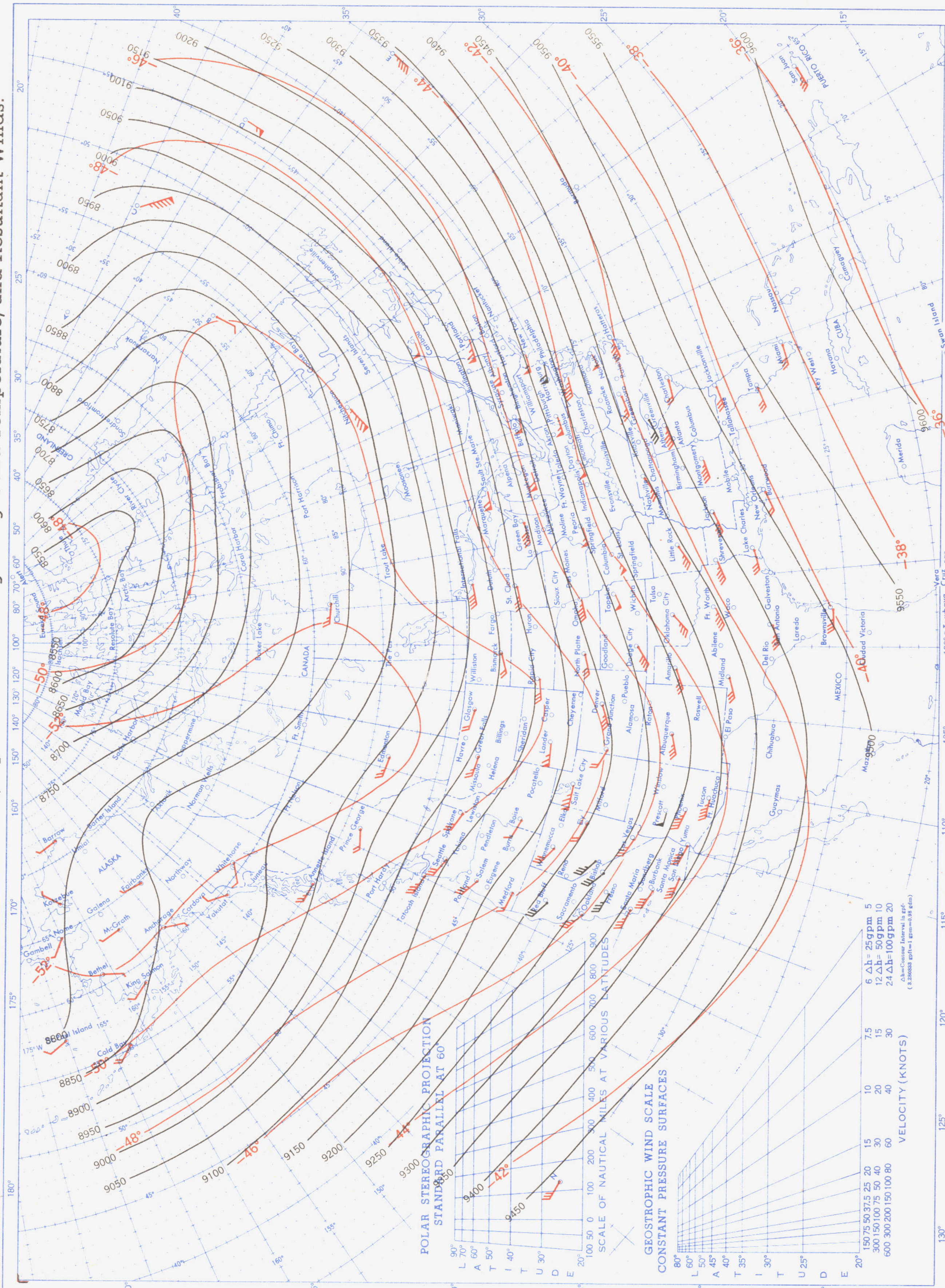
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 0300 GMT, April 1957. Average Height and Temperature, and Resultant Winds.



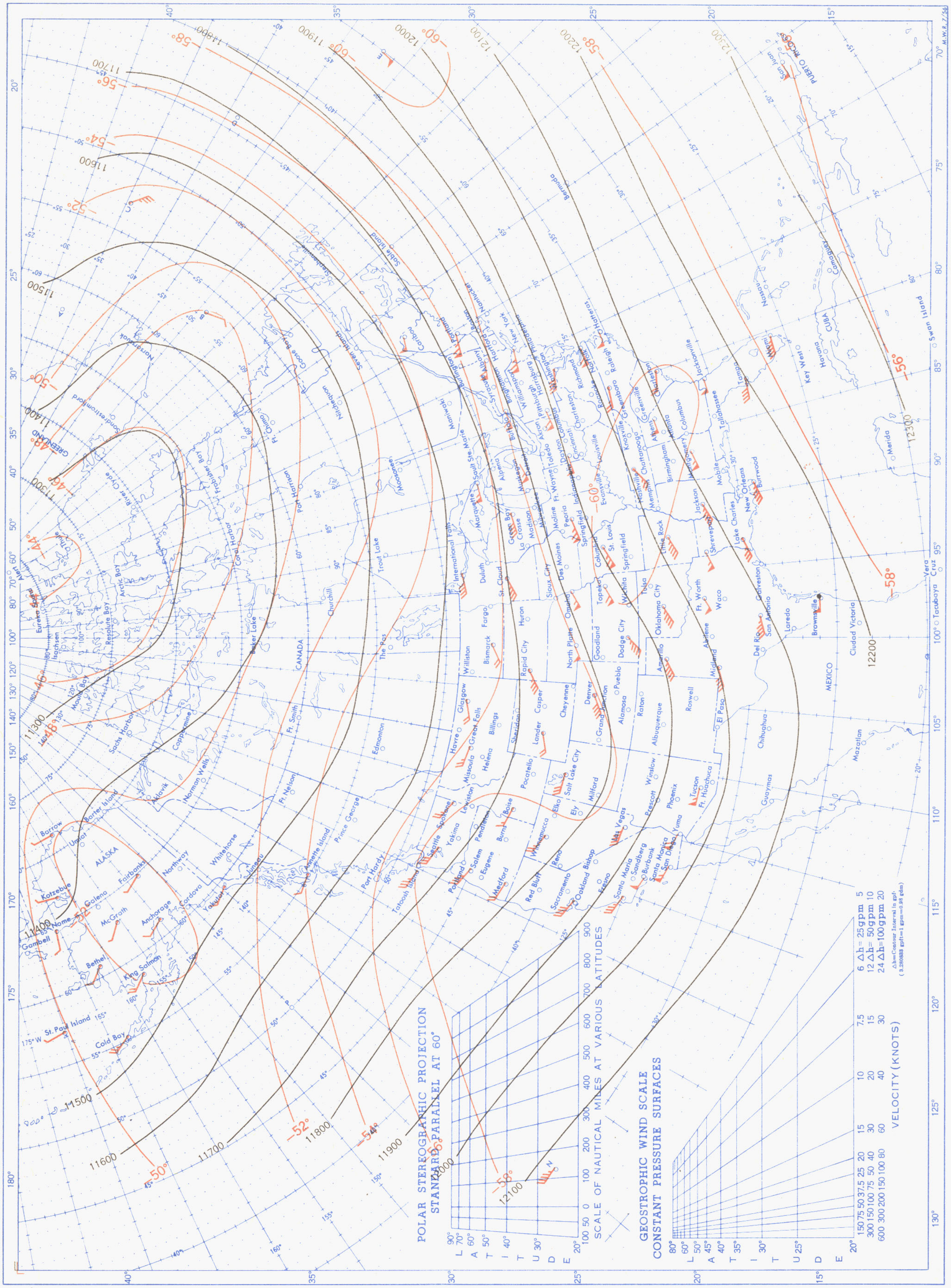
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 0300 GMT, April 1957. Average Height and Temperature, and Resultant Winds.



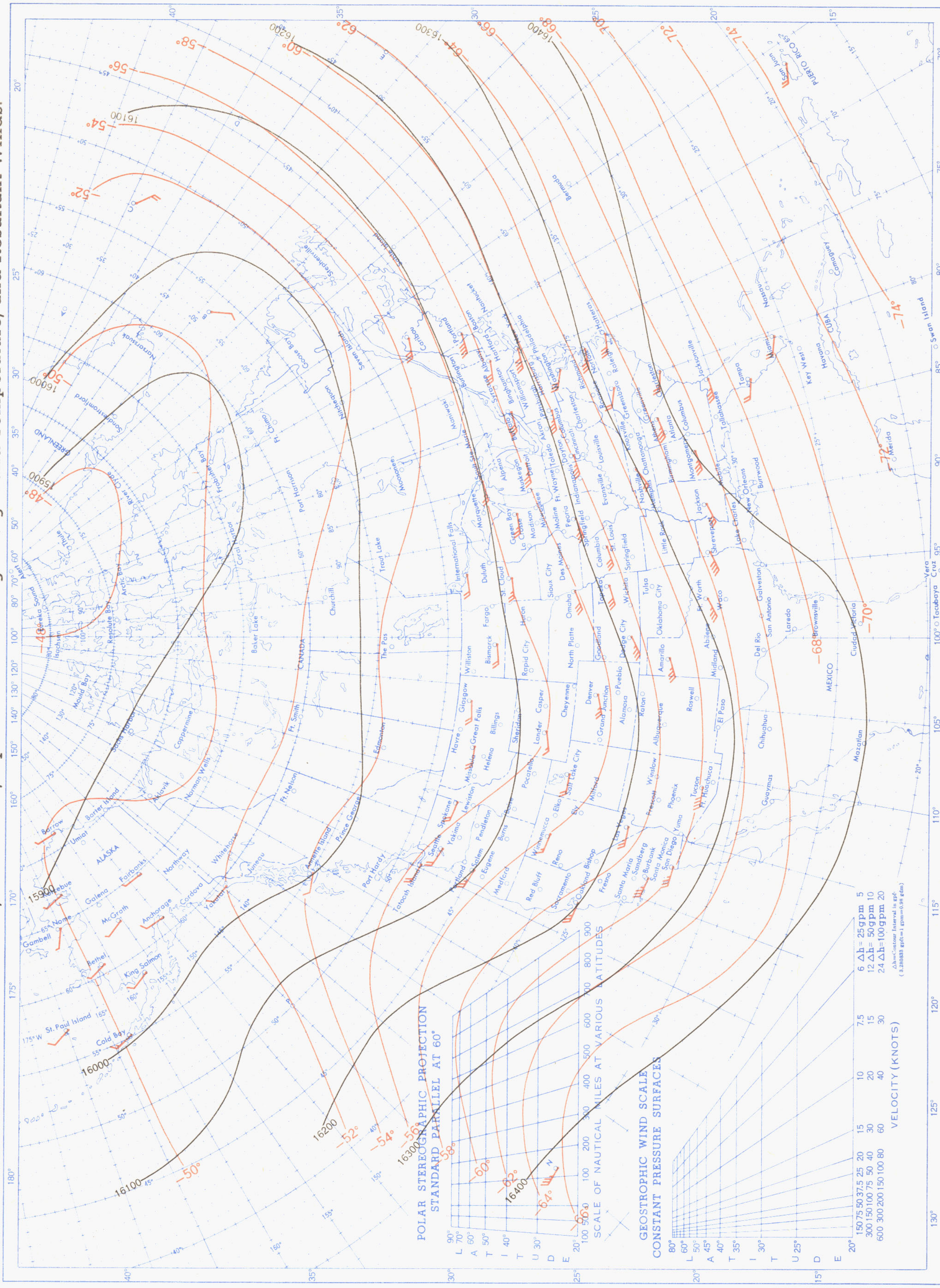
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 0300 GMT, April 1957. Average Height and Temperature, and Resultant Winds.



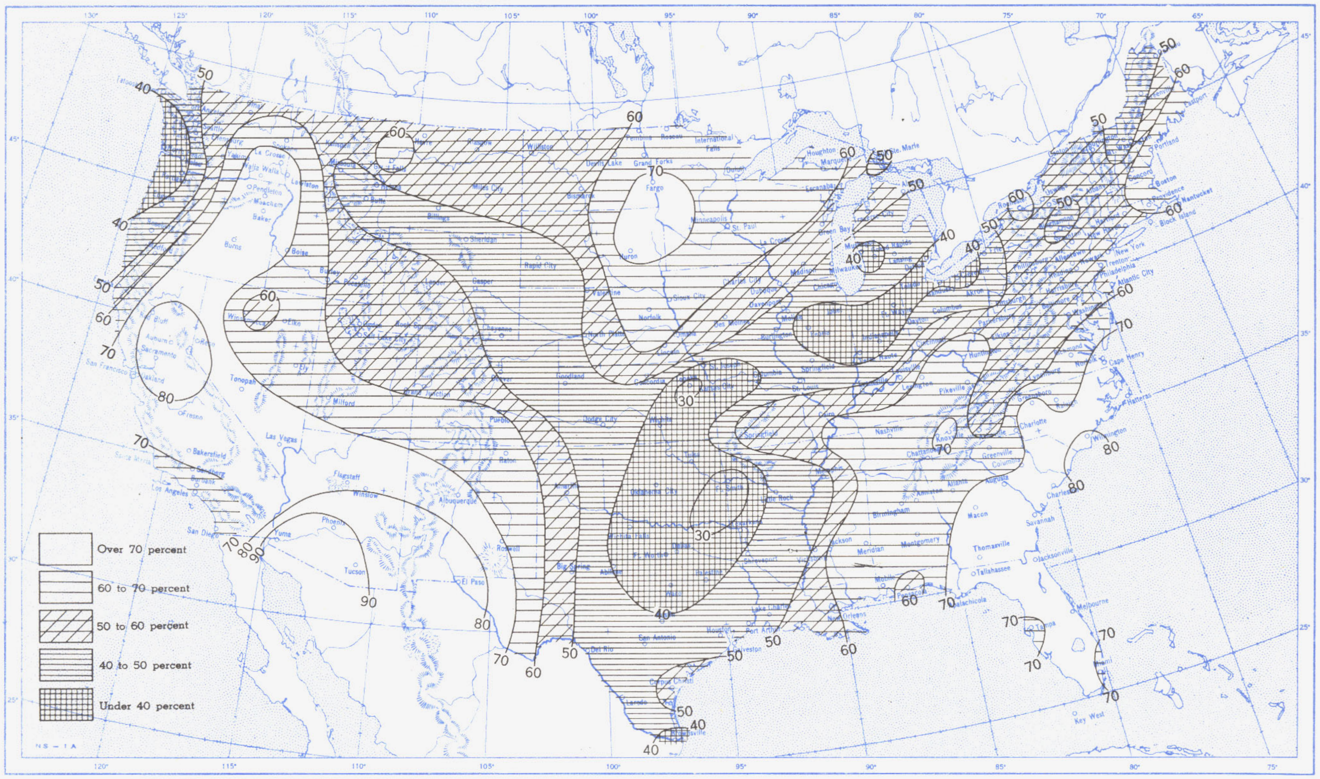
See Chart XII for explanation of map. All winds are from rawin reports.

Chart XVII. 100-mb. Surface, 0300 GMT, April 1957. Average Height and Temperature, and Resultant Winds.

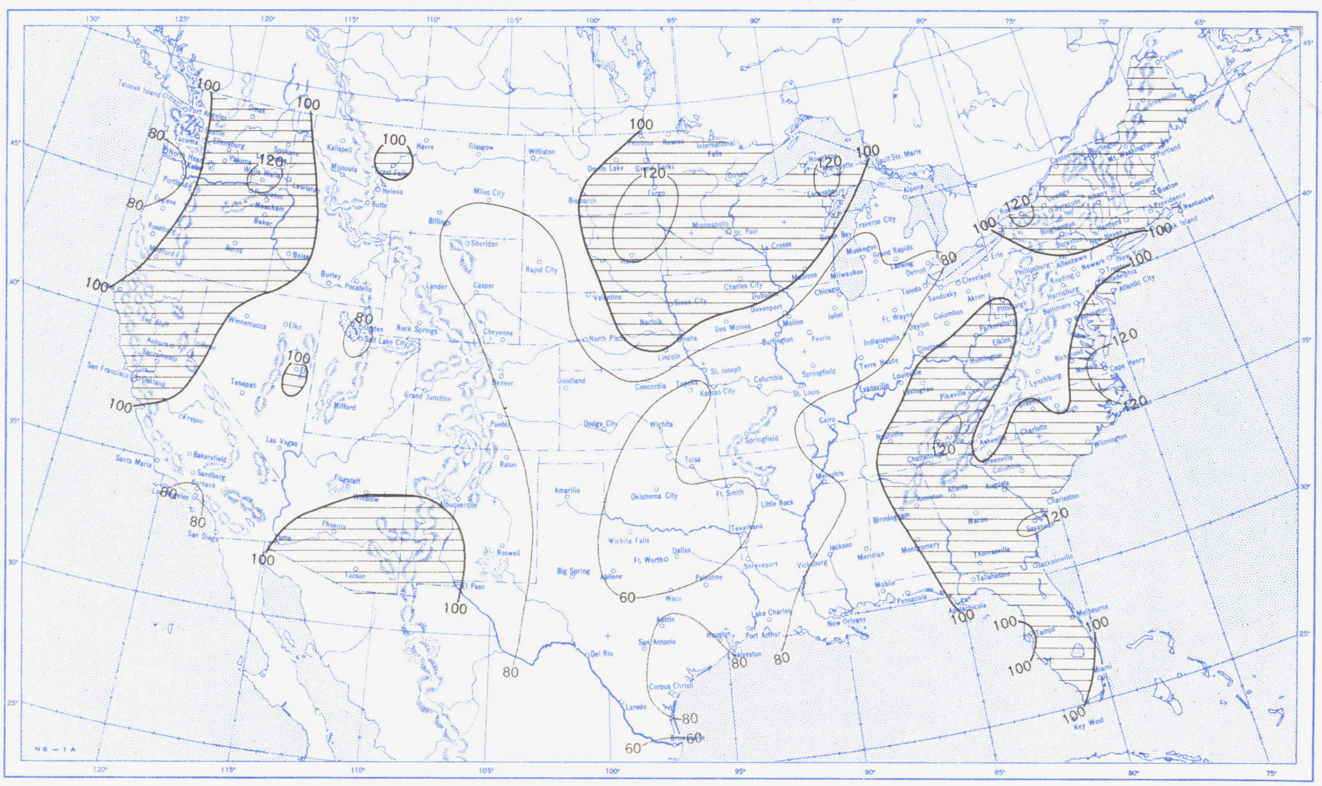


See Chart XII for explanation of map. All winds are from rawin reports.

Chart VII. A. Percentage of Possible Sunshine, April 1957.



B. Percentage of Normal Sunshine, April 1957.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.